TRANSACTIONS

of the American Society for Steel Treating

CONVENTION NUMBER

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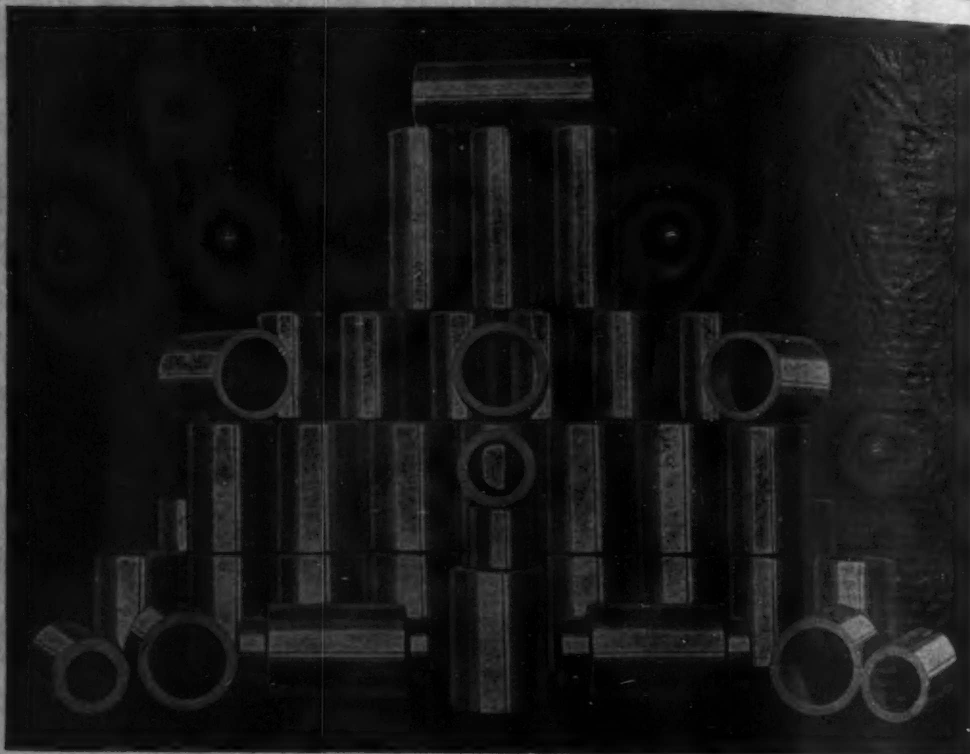


TRANSACTIONS
American Society for Steel Treating

VOL. XVI — OCTOBER, 1929 — NO. 4

NEW OFFICERS NOMINATED

IN accordance with the provision of the constitution of the American Society for Steel Treating, the National Nominating Committee for 1929 duly elected by the chapters of the society, met on Monday morning, September 9, 1929, at 10:00 A. M., in the Hotel Cleveland, and nominated the following members of the society as officers and directors of the society:

For President .... ROBERT G. GUTHRIE
For Vice-President .... J. M. WATSON
For Treasurer .... A. ORAM FULTON
For Director .... O. E. HARDER
For Director .... W. B. COLEMAN

The constitution of the society as approved at the annual meeting of the society, Wednesday, September 21, 1927, provides that if no other candidates for officers or directors be nominated as provided in Article XI, Section 4, subdivision C, then the national secretary shall notify the tellers, who shall certify the election of the candidates nominated. This method of election renders unnecessary the sending out of letter ballots where there are no nominations other than those presented by the regular nominating committee.

BIOGRAPHIES OF NOMINEES

Robert G. Guthrie

Nominated President of the Society

ROBERT G. GUTHRIE, of Chicago, is chief metallurgist of the People's Gas Light and Coke Company. He served on the Board of Directors of the Society in 1925 and '26 and as vice-president during 1929 and has also been chairman of the Chicago Chapter, American Society for Steel Treating.

ROBERT G. GUTHRIE

Nominee for President of the Society for the Year 1930

J. M. WATSON
Nominee for Vice-President of the Society for the Year 1930

A. ORAM FULTON
Nominee for Treasurer of the Society for Two Years (1930-31)

W. B. COLEMAN
Nominee for Director of the Society for Two Years (1930-31)

DR. O. E. HARDER
Nominee for Director of the Society for Two Years (1930-31)

Mr. Guthrie specializes in high power metallography which he applies in his research work for the many industrial consumers of gas in the Chicago district. He has made many contributions to professional journals, his latest having been almost entirely in the field of metallography.

Mr. Guthrie is 39 years old. He has been engaged in mining and metallurgy of iron and steel since the beginning of his career.

John Mitchell Watson

Nominated Vice-President of the Society

JOHN MITCHELL WATSON was born at Providence, R. I., in the year 1883. He attended the University of Michigan, receiving his B. S. degree in 1909.

He has been associated with the Texas Portland Cement Company of Dallas and the Packard Motor Car Corporation of Detroit as chemist. In 1910, he became engineer of tests with the Sheldon Axle Company, Wilkes-Barre, Pa., and later accepted his present position as metallurgical engineer with the Hupp Motor Car Corporation at Detroit.

Mr. Watson is the author of a paper on the "Practical Aspects of Metallurgical Work," presented as a part of the symposium on metallurgical education given at the Detroit Convention of the American Society for Steel Treating in 1922. He also presented a paper entitled, "Heat Treatment of Automotive Parts," before the Convention of the A. S. S. T. held in Boston, 1924. He is a member of the Society of Automotive Engineers, the American Society for Testing Materials and the British Iron and Steel Institute.

Mr. Watson has rendered invaluable service to the American Society for Steel Treating, having been treasurer for the past two years.

A. Oram Fulton

Nominated for Treasurer (1930-'31)

A. ORAM FULTON was born in Johnstown, Pa., September 3, 1885, and received his early education in the public and high schools of New Castle, Pa. In the fall of 1904 he entered Lehigh University, graduating with the degree of M. E.

From 1908-10 he was associated with the Winchester Repeating Arms Company at New Haven, in the capacity of foreman of steel

treating and experimental engineer on steel. He went with Wheelock, Lovejoy Company, Boston, in 1910, to develop a special line of alloy steels and became sales engineer and metallurgist with this company. In 1919 he became vice-president and, in 1924, president of this organization and is still serving in this capacity.

In addition to his duties as president of Wheelock, Lovejoy and Company, Mr. Fulton is interested in two of the greater Boston banks, serving as director of the Newton Trust Company, Newton, Mass., and director and member of executive committee of the Central Trust Company, Cambridge, Mass.

Mr. Fulton has served as a member of the finance committee of the American Society for Steel Treating since 1924.

Dr. O. E. Harder

Nominated for Director for Two Years

DR. O. E. HARDER is professor of metallography, University of Minnesota, Minneapolis, Minn. Dr. Harder has received the following education and has been active in the societies mentioned:

A. B., Oklahoma, '10; A. M., '11; Ph. D., Illinois, '15; Instructor in Chemistry, Oklahoma, '10-'11; Food Analyst, Kansas State Board of Health, Kansas, '11-'13; Fellow in Chemistry, Illinois, '13-'15; Research Chemist, Committee C-9, American Society for Testing Materials, and Portland Cement Association, '15-'18; The N. K. Fairbanks Co., 1918; Fellow in The Mellon Institute, '18-'19; Associate Professor of Metallography, University of Minnesota, 1919-23; Professor of Metallography, Minnesota, 1923, to date.

The degrees were all taken with chemistry as the major; however, for the Doctor's degree, specialization was in metallography and research was on the alloys of cobalt, nickel, and chromium.

Dr. Harder is a member of the American Association for Advancement of Science, American Chemical Society, American Institute Mining and Metallurgical Engineers, American Society Testing Materials, American Society for Steel Treating, Sigma Xi, Phi Lambda Upsilon, Alpha Chi Sigma, Association for Promotion of Engineering Education, Engineers' Club of Minneapolis. Chairman North West chapter A. S. S. T., 1921-1922, President Minnesota Section American Chemical Society, 1924-25.

W. B. Coleman

Nominated for Director for Two Years

W. B. COLEMAN was graduated from the Hill School of

Pottstown, and from the University of Pennsylvania, having specialized in engineering and chemistry. His industrial experience covers work in metallurgical laboratories; charge of foundry and open-hearth furnaces at the Midvale Steel Company; superintendent of the open-hearth department of the Coatesville works of the Midvale Steel and Ordnance Company; superintendent of the Tacony Ordnance Company and the Tacony Steel Company. During the war Mr. Coleman was civilian consultant to the Ordnance department in Washington on all gun steel manufacture.

He is now associated with W. B. Coleman and Company of Philadelphia, which company handles consulting work along metallurgical lines covering various phases of open-hearth and electric steel manufacture, the processing of steel and heat treatment, iron and steel foundry work, power plant design and operation, and laboratories for conducting chemical analysis, metallurgical and physical testing. Mr. Coleman has rendered valuable service to the society, having been chairman of the Philadelphia Chapter in 1927, chairman of the meetings and papers committee, 1927-29, and chairman of the Publication committee, 1929, which position he still holds.

PRESS COMMENTS ON THE CONVENTION AND EXPOSITION

IN a nine-page review of the National Metal Congress and National Metal Exposition held in Cleveland, September 9 to 13, 1929, *Iron Trade Review* says in part in its September 19 issue under the heading, "Steel Treater Interest is High During Annual Convention."

"High interest and splendid attendance at technical sessions marked the eleventh annual convention of the American Society for Steel Treating in Cleveland, Sept. 9-13. Although the nitriding symposium of the closing day attracted the record audience of close to 600, the Campbell Memorial lecture of Dr. Albert Sauveur and the melting practice session drew noteworthy crowds. Few technical societies command member interest as does this organization of metals technicians.

"Evidence of the solidarity and worth of the society was gained from annual reports of the officers. Service to industry has increased, likewise the membership gained 16 per cent and reached

a total of more than 5,600. Interest in the National Metal exposition, through which 50,000 people passed this year, emphasizes the rapid progress being made in the manufacture, the treatment and fabrication of metals."

Editorially, *Iron Trade Review* comments as follows:

"Established but nine years ago, the American Society for Steel Treating has a record of achievement which would credit well an organization of greater age. The National Metal Congress and exposition held in Cleveland last week was sponsored and organized by this society and constituted noteworthy contributions to the making, treating and fabrication of metals.

"Five of the country's leading technical groups co-operated in the program of the congress, a program which brought together the largest group of metals experts ever to assemble. During five days more than 50,000 people visited the exposition displaying improved materials and equipment for a wide variety of purposes. Developments of new metals and processes are announced so rapidly that only by an interchange of information and first-hand observations can one remain well versed in his profession.

"That technical papers and discussions serve a worthwhile purpose was proved thoroughly last week when every organization participating in the congress reported heavy attendance at sessions. The American Society for Steel Treating always has had unusually well attended meetings but all previous records were surpassed in Cleveland. A symposium on nitriding attracted 600 and no morning session drew less than 400.

"Succeeding congresses and expositions probably will be fashioned after the 1929 accomplishment, with other technical groups participating as advantages of an annual metal week become established. And as long as the demand for technical knowledge remains at its present level, success will attend the undertakings."

In a ten-page report of the exposition and conventions held in Cleveland, September 9 to 13, 1929, *Iron Age* of September 19, comments as follows:

"Greatest meeting of metal men ever held"—these were the words of Dr. Zay Jeffries, president of the American Society for Steel Treating, at the annual banquet of the National Metal Con-

gress held in Cleveland, Sept. 9 to 13, inclusive. Facts seem to bear out this statement.

"In numbers the total registration of members and guests showed 5,840, the largest enrollment in some years, due, perhaps, to the general acceptance by industries at large of the national metal congress idea. In technical contributions, again, almost every phase was covered and their high grade was generally acknowledged. In enthusiasm, one could hardly ask for more. In smoothness of operation and handling, the congress was eminently successful. In displays at the exposition—while not larger than previous ones, in diversity, scope and attractiveness the exhibits left little to be desired.

"Thomas A. Edison was made an honorary member of the steel treaters. In his enforced absence by illness, acceptance was expressed in his behalf by Harvey Firestone, Sr., a lifelong friend.

"A symposium on nitriding and a session on steel metallurgy were impressive features. At the exhibit late developments in rustless iron, tungsten-carbide tools, and nitrided steels were most prominent. Attendance at the National Metal Exposition was reported by Secretary Eisenman as 53,121.

"Comment was heard on every side regarding the unusual excellence of the technical papers this year. This was particularly true of the 35 papers scheduled for the ten sessions of the A. S. S. T. Besides these there were 20 papers contributed to programs for the American Welding Society, 18 for the Institute of Metals Division and 10 for the Iron and Steel Division of the American Institute of Mining and Metallurgical Engineers, as well as 11 for the Iron and Steel Division of the American Society of Mechanical Engineers—94 in all for the week.

"A climax was reached on the last day of the A. S. S. T. sessions. This was devoted to a symposium on nitriding. The society has never held so important a meeting nor one so largely attended—evidence of the keen interest in this new development. Dr. Adolph Fry of Germany, who originated the process, and Dr. Pierre Aubert of Paris, the commercial developer, were present and spoke. Eight papers and an address by Doctor Fry were presented and briefly discussed.

"Another splendid A. S. S. T. session was devoted to steel manufacture. Besides these there were over 20 papers on a variety of subjects."

The September 19 issue of the *American Machinist* writes of the National Metal Congress and Exposition as follows:

"With an attendance of 9000 on the opening day, the National Metal Exposition established a new record at Cleveland last week. Four national engineering societies held meetings in connection with the exposition and congress, the American Society for Steel Treating, having headquarters at the Hotel Cleveland, the American Welding Society, having headquarters at Hotel Statler, the Institute of Metals Division and the Iron and Steel Division of the American Institute of Mining and Metallurgical Engineers and the Iron and Steel Division of the American Society of Mechanical Engineers, having headquarters at Hotel Cleveland, Public Auditorium, respectively. The divisions of the two societies also held joint technical sessions with the other societies.

"Many foreign engineers *en route* to the World Engineering Congress at Tokyo, in October, stopped off to attend the various technical sessions and to see the exposition. Thomas A. Edison was also expected to attend and was made an honorary member of the American Society for Steel Treating at the annual banquet on Thursday night, September 12, although he was too ill to attend.

"Chief among the innovations in the show were the great number of new alloys. Alloys for cutting, heat-treating, stain, acid, wear and corrosion resisting, and a number of other special uses were introduced by the more than 300 exhibitors. Also notable was the variety of rods shown in the welding section, together with many new types of welding apparatus. Several newly imported foreign machines were also on exhibition, as well as a number of domestic furnaces and machines."

The following is an excerpt from one of the several articles published in the September 21 issue of *Automotive Industries:*

"The Eleventh Annual National Metal Exposition which was held last week in the Public Auditorium and Annex in Cleveland was fully up to the high mark set by the shows of previous years. The exposition was well staged and well managed, and the public interest was keen. In fact, the writer does not remember a single previous exposition of strictly industrial goods, that is, of articles other than those for family consumption, to which the general public flocked in such large numbers.

"During the several evenings the show was open, the scene it presented was very much reminiscent of automobile shows in the large cities, there being continuous processions up and down the aisles, and large crowds collecting around stands at which demonstrations were being given or which contained exhibits of particular appeal.

"AIRCRAFT PARTS FAVORED. The show was supported by three important industries. The principal one was the steel industry, and most of the steel works had stands at which they exhibited machines and parts made of their steels, test specimens and other evidences of the qualities of their products. Aircraft parts have become favorite exhibition material with steel makers. Crankshafts and connecting rods in the finished state were shown at quite a number of stands. Aircraft work, of course, calls for steel of the highest quality, and besides, the completely finished parts of aircraft engines make rather attractive exhibits.

"The second industry taking a major part in the exposition was that of heat-treating equipment. Its products included furnaces of various kinds, refractories, heat resisting metals and various articles made therefrom and used in heat-treating operations; temperature-control equipment, metallographic and mechanical testing equipment, carbonizing and quenching materials.

"The third participating industry was that of welding machines and welding equipment and materials. Many of the furnaces and welding machines were shown in operation, and gas cutting was also demonstrated.

"Points of particular automotive interest at the show were exhibits of the new super high-speed cutting alloys of stainless or nonrusting steels, and of nitrided steels."

The *American Machinist* in its September 26 issue says:

"An 'alloy age,' as a fitting materials accompaniment to the requirements of this era of automatic machinery, in contradistinction to the fading age of ordinary iron and steel, was the keynote of the National Metals Congress, held in Cleveland from September 9 to 13. Alloys for many uses were featured, the outstanding classes being high-speed cutting alloys, corrosion-resistant steels and irons, high-tensile light alloys, high-test irons, die-casting metals, alloy welding rods, and a wide range of alloy tool steels to give almost any desired property."

NATIONAL METAL CONGRESS AND EXPOSITION AND THE ELEVENTH ANNUAL CONVENTION OF THE AMERICAN SOCIETY FOR STEEL TREATING, CLEVELAND, SEPTEMBER 9 TO 13, 1929

THE week of September 9th was an epoch-making one in the field of metals and metal working. It marked the largest assemblage of men vitally interested in the metals art and kindred industries in the history of the world and was international in scope. While the gathering was known as the National Metal Congress, it might well have been known as the international metal congress, since there were many from foreign countries in attendance at this Congress in Cleveland. A few of these were:

Dr. Pierre F. M. Aubert, Aubert Freres et Duval, Paris, France
Dr. Adolph Fry, Krupp Research Laboratories, Essen, Germany
Waldemar O. Freyberg, professor, Polytechnical Institute, Harbin, Manchuria, China
C. K. Everitt, Works manager, Edgar Allen & Co., Ltd., Sheffield, England
Ernest Hoessrich, engineer, Gunther & Co., Frankfurt-am-Main, Germany
Dr. F. Koerber, director of the Kaiser Wilhelm Institute, Germany
W. D. Pugh, research assistant, English Steel Corporation, Sheffield, England
Dr. Otto Petersen, president of the German Iron and Steel Institute
Cesare Parone, Milan, Italy
T. Nago, Japanese Army
Dr. E. H. Shulz, director of the research institute of the Vereinigte Stahlwerke, A-G., Germany
M. Sakata, Japanese Navy
Dr. M. Suzuki, chief of materials section, Japanese Gov't Railways, Tokio, Japan
W. E. Siler, inspector of tools, Canadian National Railways, Winnipeg, Manitoba
Fernand Turretini, director general, Societe Genevoise d'Instruments de Physique, Geneva, Switzerland
M. M. Yaskolka, mechanical engineer, tractor department, Krasug Putilovetz plant, Leningrad, Russia
J. D. Volckman, sales engineer, James W. Pyke, Montreal, Canada
F. A. H. Lantsberry, Wm. Jessop & Sons, Sheffield, England

The National Metal Congress combined the meetings of five different societies—it was the Eleventh Annual Convention of the American Society for Steel Treating, the Ninth Annual Convention of the American Welding Society and the regular fall meeting of the Institute of Metals and Iron and Steel Divisions of the American

Institute of Mining and Metallurgical Engineers and the Iron and Steel Division of the American Society of Mechanical Engineers.

Each of the above societies sponsored their own technical sessions which were held simultaneously with the National Metal Exposition. The registration of the combined societies was in excess of 7000, with 5840 registered in attendance with the American Society for Steel Treating (more than 50 per cent of the entire membership); 350 with the American Welding Society; 200 with the Institute of Metals Division and the Iron and Steel Division of the American Institute of Mining and Metallurgical Engineers and 100 with the Iron and Steel Division of the American Society of Mechanical Engineers.

The exposition and convention of the five societies was indeed a successful affair. The National Metal Exposition located in the Cleveland Public Auditorium occupied over 80,000 square feet of floor space and was enthusiastically acclaimed a great success by exhibitors and guests alike. Here, more than two hundred fifty of the leading manufacturers of the metal world exhibited the latest methods and equipment that touch on the production, selection, fabrication, treatment, inspection, welding and use of every kind of metal. Many of the exhibits were in operation. The total attendance during the week was accurately counted by door guards as 53,121.

Again this year, as for the last two years, the American Welding Society combined their welding exhibit with that of the National Metal Exposition, augmenting both their own exposition and that of the Steel Show. We are pleased to announce that the American Welding Society, the Institute of Metals Division and the Iron and Steel Division of the American Institute of Mining and Metallurgical Engineers and the Iron and Steel Division of the American Society of Mechanical Engineers will again take part in the activities of the National Metal Congress and Exposition which will be held in the Hotel Stevens, Chicago, the week of September 22, 1930.

Each of the five cooperating societies held technical sessions throughout the week. The American Welding Society held their morning meetings at their headquarters hotel, the Hotel Statler, and their afternoon meetings at the Public Auditorium; The American Society for Steel Treating, the Institute of Metals Division and the Iron and Steel Division of the American Institute of Mining and Metallurgical Engineers, likewise held their morning meetings at their headquarters hotel, the Cleveland, and their afternoon meet-

ings at the Public Auditorium; and the Iron and Steel Division of the American Society of Mechanical Engineers at the Hollenden Hotel and the Auditorium. There were some 92 papers in all read before these five societies throughout the week, 34 of which were on the program of the American Society for Steel Treating.

For the benefit of those members of the society who were unable to be in Cleveland during the National Metal Congress and Exposition this year, we are publishing in this issue of TRANSACTIONS a review of the activities of the program for the week of September 9, 1929, which constituted the convention and exposition of the five societies. The events are arranged in chronological order.

The exposition was open each day at the Cleveland Public Auditorium from 12:00 noon until 10:00 P. M., with the exception of Tuesday and Thursday, on which days the exposition closed at 6:00 P. M.

The technical sessions of the American Society for Steel Treating were better attended this year than ever before with an attendance at each session of 500 to 600. Again, an accurate time schedule had been arranged and was carefully carried out for each technical session and this, as in the past, was found to work out admirably and met with unanimous approval of all who attended the sessions. The use of the public address system of voice amplification proved to be unusually helpful to speakers and discussors in addressing the large assemblages.

For the fifth consecutive year *Daily Metal Trade* published a *Steel Treaters' Daily*, which gave a comprehensive review of the activities during the National Metal Congress. Four editions were published and distributed at the Convention, and copies were likewise mailed to the home addresses of all members of the society.

MONDAY, SEPTEMBER 9

The first technical session of the Eleventh Annual Convention of the American Society for Steel Treating was called to order at 10:00 A. M., by W. H. White, chairman of the Cleveland Chapter, in the ballroom of the Hotel Cleveland. After a few introductory remarks, Mr. White called upon Dr. Zay Jeffries, the national president of the society and a resident of Cleveland, who welcomed the guests and participating societies in the name of the American Society for Steel Treating. Dr. Jeffries then turned the meeting over to Robert M. Bird, past president of the society and chairman

GENERAL VIEW OF THE ARENA

of this meeting. Chairman Bird immediately proceeded with the technical program for the morning, consisting of a schedule of four papers, which were as follows:

10:15 A. M.—*Dilatation of Steel During Quenching*—G. M. Eaton, Molybdenum Corp. of America, Pittsburgh.
10:45 A. M.—*The Economical Reuse of Solid Carburizing Materials*—H. B. Knowlton, International Harvester Co., Fort Wayne, Ind.
11:15 A. M.—*The Selection of Case Hardened Steels for Highly Stressed Gears*—H. W. McQuaid and O. W. McMullan, Timken-Detroit Axle Co., Detroit.

Each of these papers was presented by its respective author and in the case of the last paper the junior author made the presentation. The prearranged time schedule was closely followed, but much interesting and valuable discussion was presented.

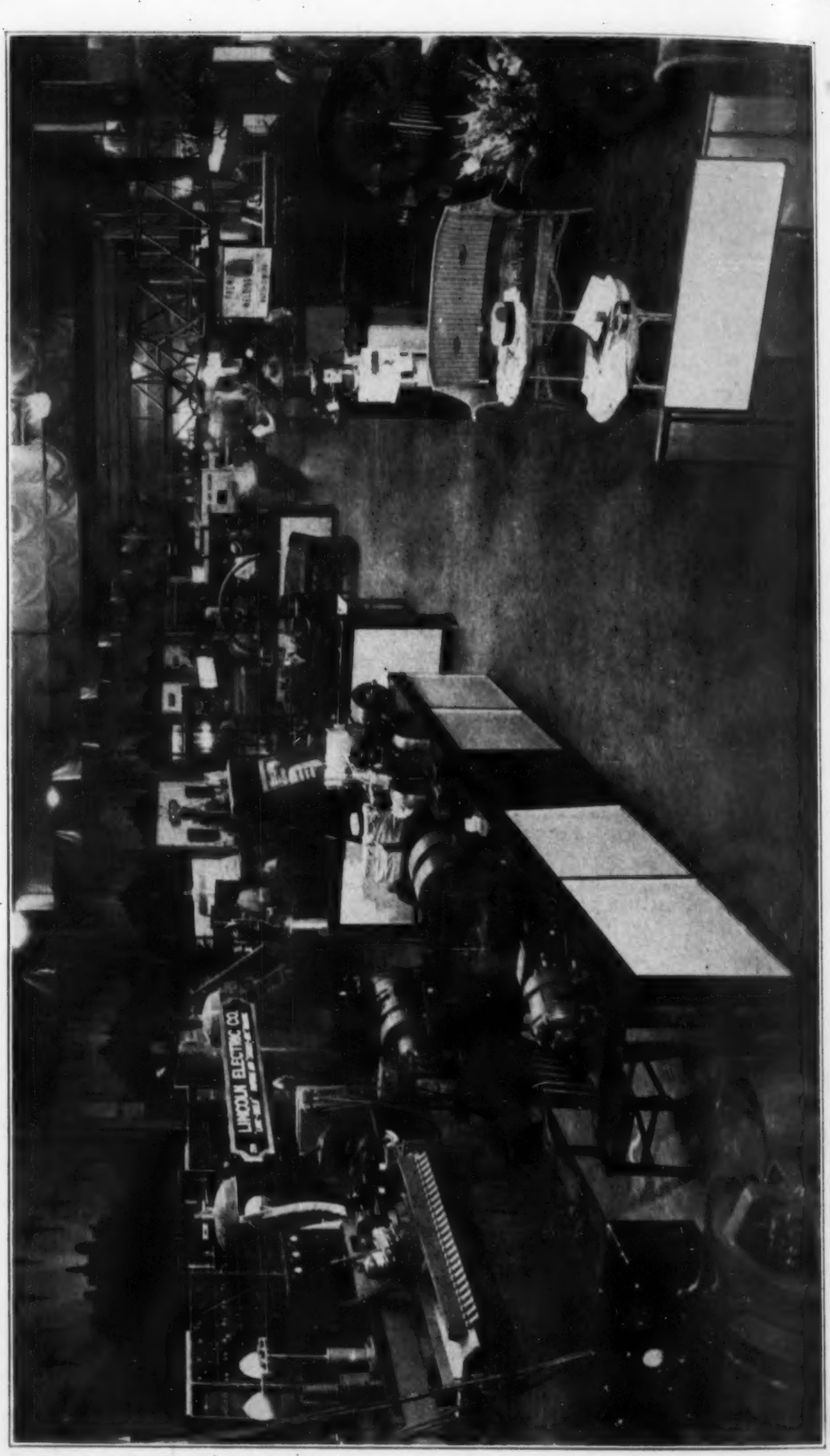
The second technical session was held in Club Room B of the Cleveland Public Auditorium and was called to order by Professor Bradley Stoughton at 2:00 P. M., who was assisted by Robert Atkinson as vice-chairman. Four papers were scheduled for this meeting and were presented in the following order:

2:00 P. M.—*Conditions Necessary for Blistering of Metal During Processing* Dr. Anson Hayes, American Rolling Mill Co., Middletown, Ohio.
2:25 P. M.—*Dendritic Steel*—H. G. Keshian, Chase Metal Works, Waterbury, Conn.
3:00 P. M.—*Improving of Refractory Lining of Heat Treating Furnaces for High Temperature Annealing of Steel Castings*—W. J. Merten, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.
3:30 P. M.—*Overheating of Steel for Forging*—W. E. Jominy, University of Michigan, Ann Arbor, Mich.

As in the case of the morning session, much valuable written and oral discussion was presented. All of this discussion will appear in TRANSACTIONS at the time when the respective papers are published.

TUESDAY, SEPTEMBER 10

The Tuesday morning session of the Convention was called to order at 10:00 A. M. by Mr. Radclyffe Furness, Dr. C. H. Herty serving as vice-chairman. Four interesting papers were presented at this session which dealt largely with the melting of steel. As in the case of the Monday technical meeting this session was well attended and considerable worth-while discussion was presented, both in written and oral form. All of this discussion will appear later in TRANSACTIONS. The papers presented are as follows:



GENERAL VIEW OF WELDING SECTION

10:00 A. M.—*Production of Electric Steel for Castings*—George Batty, Steel Castings Development Bureau, Philadelphia.

10:30 A. M.—*Slags Produced in Steel Making, Their Effects on the Product and on the Process Itself*—G. A. Dornin, Gathmann Engineering Co., Baltimore.

11:00 A. M.—*Melting Practice for Three Types of Electric Steel*—H. P. Rassbach, Midvale Co., Nicetown, Philadelphia.

11:30 A. M.—*Locomotive Forgings*—Lawford H. Fry, Standard Steel Works, Burnham, Pa.

The afternoon session was called to order at 2:00 o'clock by Chairman H. J. Stagg, assisted by A. H. d'Arcambal as vice-chairman. Four papers were scheduled for presentation at this meeting, and all but one of them were presented by their respective authors.

2:00 P. M.—*Methods of Tests for Determining the Machinability of Metals in General with Results*—O. W. Boston, University of Michigan, Ann Arbor, Mich.

2:30 P. M.—*On the Distribution of Hardness Produced by Cold Working*—W. P. Sykes, General Electric Co., Cleveland, and A. C. Ellsworth, Thompson Products Co., Cleveland.

3:00 P. M.—*Inherent Hardenability Characteristics of Tool Steel*—B. F. Shepherd, Ingersoll-Rand Co., Phillipsburg, N. J.

3:45 P. M.—*Some Notes on the Behavior of Carbon Tool Steel on Quenching*—G. V. Luerssen, Carpenter Steel Co., Reading, Pa.

In the absence of the author of the third paper, S. C. Spalding of Syracuse, N. Y., presented the paper. The ensuing discussions will be printed in TRANSACTIONS along with the respective paper.

GRAND BALL

One of the interesting annual functions of the society is the informal dancing party which has become a social event which is looked forward to by many members. This year the party was held in the ballroom of the Hotel Cleveland and a large number of members and guests were in attendance. The excellent music furnished for this event helped to make this a most enjoyable evening for everyone.

WEDNESDAY, SEPTEMBER 11

As has been the custom for the past few years the Annual Meeting of the Society was held on Wednesday morning. The meeting was called to order by President Jeffries at 9:30 A. M. and consisted of a general business meeting wherein the president presented his annual address, the secretary his annual report and the treasurer his report upon the finances of the society. The three reports follow in their correct order.

ANNUAL REPORT OF THE SECRETARY

WILLIAM HUNT EISENMAN, *Secretary*

HONORARY MEMBERS

It is with deep regret the Society records the death of one of its Honorary Members, Mr. Charles F. Brush, which occurred at Cleveland on June 15.

HENRY MARION HOWE MEDAL

The Henry Marion Howe Medal was awarded for the sixth time at the annual banquet at Philadelphia last year, the 1928 recipients being Doctors O. E. Harder and R. L. Dowdell, joint authors of the paper entitled "The Decomposition of the Austenitic Structure in Steel." This was judged the paper of highest merit published in the TRANSACTIONS during the twelve months from August, 1927, to August, 1928.

EDWARD DE MILLE CAMPBELL MEMORIAL LECTURE

The third Campbell Memorial Lecture, entitled, "The Application of Science to the Steel Industry," was presented on the day of the annual meeting at Philadelphia in 1928, by Dr. W. H. Hatfield of the Brown-Firth Laboratories, Sheffield.

MEMBERSHIP

The American Society for Steel Treating on August 31 had a membership of 5615. Of this number 4844 or 86.5 per cent were of member classification; 522 or 9.3 per cent of sustaining classification; 228 or 4.06 per cent of junior classification; 8 or .14 per cent honorary members and two founder members. This is 16.0 per cent increase over the preceding year.

Table I shows the increase in total membership since 1920.

Table I
A. S. S. T. Membership 1920-1929

Year	Members	Assoc.	Sustain.	Jun.	Hon.	Fndr.	Total Mem.	Increase	% Increase
1920	1349	302	50	21	2	0	1724	...	...
1921	1742	341	56	25	4	0	2168	444	25.7
1922	1798	375	86	48	6	0	2313	145	6.7
1923	2048	400	191	99	6	2	2746	433	18.7
1924	2224	476	209	109	6	2	3026	280	10.2
1925	2452	500	243	160	6	2	3363	337	11.1
1926	2916	580	303	190	8	3	4000	637	18.9
1927	3436	608	382	217	11	3	4653	653	16.3
1928	4175	...	444	214	9	2	4844	191	4.1
1929	4844	....	522	228	8	2	5615	771	16.0

MEETINGS OF BOARD OF DIRECTORS

The Board of Directors held five meetings during the past year as follows:

Philadelphia, Sunday, October 7, 1928.
Philadelphia, Wednesday, October 10, 1928.
Philadelphia, Thursday, October 11, 1928.
Cleveland, Friday, February 12, 1929.
Cleveland, Monday, July 29, 1929.

Semi-Annual Meeting and Western Metal Congress

The Semi-Annual meeting of the Society for 1929 was held in Los Angeles during the week of January 14. At the same time the Western Metal Congress and the Western States Metal and Machinery Exposition were held under the auspices and direction of the Society. Twelve national societies having groups on the Pacific Coast, co-operated with the A. S. S. T. in preparation and presentation of the program.

The meetings of the Congress were exceptionally well attended, the number varying from 200 to 500.

The Western States Metal and Machinery Exposition held simultaneously with the Congress was a notable event with an attendance of 54,000 and some 175 exhibitors occupying approximately 35,000 square feet of floor space.

Chapters and Groups

Chapters have continued their splendid meetings. Programs of exceptional merit have been the general rule and the Society and the chapters are greatly under obligation for the splendid support and co-operation of the many speakers appearing on their programs.

The President's bell, awarded by the president each year, has during the past year been in possession of the Philadelphia Chapter.

During the year a new group of the Society was organized at Newark, starting out with a membership of approximately 75 and having at the end of August a membership of 150.

The financial condition of the chapters continues to be highly satisfactory. The total assets of the chapters at the close of the fiscal year June 1, 1929, was $30,000.00.

Educational Activities

The Society in co-operation with Purdue University again secured the services of Prof. John F. Keller, for a period of six months during which time he conducted two groups in Engineering Extension activities.

The first group consisted of Bridgeport, Hartford, New Haven, Springfield and Worcester, with a total of 625 men registered and an average attendance of 90 per cent.

The second group consisted of four groups in the Bethlehem Steel Company's plant with a total of 540 men and a class at Newark with 106, making a total attendance of the second group of 646 and an average of 90 per cent attendance.

During the Western Metal Congress Professor Keller gave a series of five lectures on the five days of the Congress with a total enrollment of 112 with 100 per cent attendance.

For the two years during which Professor Keller has engaged in this activity for the Society, he has had 21 lecture groups with a total attendance of 2594.

Many chapters of the Society have continued their educational activities either as independent units operating their own courses or in co-operation with technical institutions.

The educational activities both of the chapter and of the extension department form a very important service of the Society to the metal industry.

Changes in the Constitution

At the annual meeting of the Society held in Philadelphia last year the Constitution and By-Laws Committee presented two changes in the Constitution. They were printed in full in the November, 1928, issue of Transactions, page 675.

The items covered by these changes were that "any member whose dues to the Society remain unpaid for a period of one calendar month after final bill has been mailed to him, shall automatically cease to be a member of the Society."

The second amendment provided authority to the Board of Directors to name a date on which dues of all members would become payable.

In compliance with the second amendment, the Board fixed the date of March 1 of each year to be the time upon which the dues for all members of the Society become payable.

Annual Report of Recommended Practice Committee

The Recommended Practice Committee held, during the past year, two full-day meetings at the National Office of the Society. The first meeting was held on November 22, 1928, and the second meeting, April 15, 1929. The Recommended Practice Committee has prepared and is carrying out a very useful and valuable program, which as it develops, will greatly enhance the services rendered by the Committee to the members of the Society.

There has been a slight increase this year in the number of technical sub-committees which have been operating under the Recommended Practice Committee. Altogether there have been 18 such committees. Four of these committees have completed their reports and have been temporarily discharged from active duty. The other 14 sub-committees are engaged in the preparation of recommended practices and reports, several of which will be completed within the near future.

The sub-committees which are at present in operation, are composed of a total of 94 members of the Society, which represents 19 of the 37 A. S. S. T. chapters and groups. There has been an increase of over 12 per cent in the membership of the sub-committees as compared to the previous year, 1927-1928.

With the exception of one or two committees, the attendance at committee meetings has been over 80 per cent which is considered excellent and strongly reflects the interest exhibited by the members of the Society, who are participating in committee activities. Eight reports have been completed by the committees so far this year, and several more are in process of preparation.

The Nonferrous Data Sheet Committee of the Institute of Metals Division of the A. I. M. E. has produced some very worth while work during this year. The committee has had prepared 19 new articles, all of which are to be published in loose leaf data sheet form for the members of the Institute of Metals Division of the A. I. M. E., and are being published from time to time in the Transactions for the A. S. S. T. members. It is estimated that the Nonferrous Data Sheet

Committee will have over 100 new pages of nonferrous information ready for the next issue of the HANDBOOK. This is quite a substantial increase over last year's production. If the Nonferrous Data Sheet Committee is as successful during the coming year with its activities, it would appear that a separate handbook devoted to nonferrous metallurgy would be desirable.

Since the publication of the A. S. S. T. HANDBOOK in bound form, the loose form data sheets are, of course, not being issued. The new material prepared by authors and committees for the HANDBOOK is being published from time to time in the TRANSACTIONS. This makes the material available, to the members, as it is prepared and approved for publication by the committees. There has been prepared by committees and authors about 160 pages, a part of which has been published in the TRANSACTIONS. With the manuscripts which are in process of preparation for publication it is estimated that over 200 pages of new material will be prepared for publication in the next edition of the HANDBOOK

The 1930 edition of the A. S. S. T. HANDBOOK will be ready for distribution to the members of the Society on or about June 1, 1930. In addition to the 200 pages of new material, the new edition of the HANDBOOK will also have a number of the original articles completely revised, thereby bringing them up-to-date with new information which has developed since their publication.

The sections, index and buyer's guide are to be more suitably arranged for the 1930 edition which will facilitate the location of desired information.

Since the first of the year, the Recommended Practice Committee has had two new members: F. T. Llewellyn and J. E. Robinson.

The Recommended Practice Committee has had a much more extensive program this year than in previous years and as a result it has been necessary to call upon a larger number of members to assist in executing this work. The Recommended Practice Committee has in all cases found everyone extremely willing to co-operate and assist with their endeavors. This willing co-operation exhibited by the large number of members engaged in the recommended practice work is deeply appreciated.

The Board of Directors is under heavy obligations for the splendid work of W. J. Merten, chairman of the Recommended Practice Committee, to the members of the committee and to the chairman and members of the numerous subcommittees whose combined efforts have produced worth while monumental work.

The splendid increase in the nonferrous section of the HANDBOOK has been due entirely to the untiring, conscientious, and capable efforts of R. S. Archer and the other members of the Nonferrous Data Sheet Committee of the Institute of Metals.

This excellent service and co-operation is greatly appreciated.

J. Edward Donnellan, the efficient secretary of the Recommended Practice Committee, has received and deserves the commendation of the Board.

TRANSACTIONS

The total editorial production for the first 16 volumes of the TRANSACTIONS is shown in the accompanying table, with a total of 15,306 pages. The number

Table II
Total Editorial Production

Transactions				Handbook		
Vol. No.	Pages				Pages	Subjects
Vol. 1	840	Vol. 10	1036	1924	110	16
Vol. 2	1238	Vol. 11	1042	1925	129	21
Vol. 3	1000	Vol. 12	1050	1926	114	13
Vol. 4	752	Vol. 13	1090	1927	86	10
Vol. 5	642	Vol. 14	972	1928	156	40
Vol. 6	816	Vol. 15	1078	1929	200	48
Vol. 7	816	Vol. 16	1050			
Vol. 8	892				793	148
Vol. 9	992	Total	15,306			

of pages, however, in Volume 16 is estimated inasmuch as Volume 16 continues through December, 1929.

During the year from September, 1928, through August 31, 1929, 12 issues of the TRANSACTIONS have been published, containing 80 papers, a total of 1781 pages. This compares with 82 papers or 1605 pages, last year.

In dividing the papers published in 3 classes, practical, semi-technical and technical, 53 per cent were of the practical class; 20 per cent were of the semi-technical class; and 27 per cent were of the technical class. In addition to the per cents as indicated for these 3 classes, there were printed in TRANSACTIONS 698 pages of Patent Reviews, Engineering Index, News of the Society, News of the Chapters and Items of Interest. The advertising space occupied 980 pages. The total number of pages published for the year, including advertising and editorial matter, is 3528.

Beginning with Volume 15, January, 1929, two main changes were made in the publication of TRANSACTIONS, namely the use of a heavier coated stock paper and a change in the cover design of the front cover, together with a change in the color of the cover stock. The use of the new coated paper permits better reproduction of half-tones and permits the use of finer screen half-tones resulting in greater detail.

PREPRINTS

At the Tenth Annual Convention held in Philadelphia 41 papers were presented, 31 of which were preprinted. This year's convention has scheduled 34 papers for presentation, 20 of which have been preprinted and distributed on July 15, 1929, to those members requesting them. The total number of pages in the preprints for 1928 was 666, whereas, the total number for 1929 is 463.

MEETINGS OF THE PUBLICATION COMMITTEE

The Publication Committee held a two-day meeting on May 24 and 25, 1929, at the headquarters office, Cleveland, at which time important matters pertaining to the work of the Committee were discussed in detail.

1928 CONVENTION AND EXPOSITION

The Philadelphia Convention of the Society brought forth a total of 41

papers, 31 of which were preprinted, which assisted materially in the large amount of valuable discussion presented.

Meeting concurrently in Philadelphia was the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, and the annual fall meeting of the American Welding Society.

The technical sessions were of unusual high merit. All records for attendance at these sessions were broken and interest continued unabated through the week.

The Exposition while not quite as large as the previous one in Detroit was complete in detail and of wide diversity. There were a total of 265 exhibitors occupying approximately 76,000 square feet of space.

Editorial comment indicates the general reception which the 1928 Convention and Exposition received throughout the industry.

Editorial Comment

Philadelphia Metal Week Successful

"Another National Metal Week has come and gone and with its passing another scientific and industrial achievement is recorded upon the pages of modern progress. Meeting in Philadelphia last week in simultaneous conventions, the American Society for Steel Treating, the American Welding Society and Institute of Metals attracted attention from the metal working industries not only from America but from abroad as well.

"Metallurgists and metal fabricators play major roles in providing for the needs of mankind. Our transportation systems, including travel on land, sea and air, are but one example of what has been accomplished through the study, development and treatment of metals and their alloys. As time passes, it might be supposed that the fields of discovery are narrowing and that our greatest strides already have been made.

"A review of the activities of last week, however, indicates that perhaps our greatest achievements lie ahead. New cutting materials are being developed, improved heat treatments are providing superior physical properties in tool steels and structural materials and new methods of joining metals together are effecting substantial economies. A visitor at any session conducted in Philadelphia last week could not but wonder as to what startling developments will result from research during the next 12 months.

"Perhaps a more tangible evidence of progress was to be gained from the National Metal Exposition where the latest furnaces, metallurgical equipment, testing apparatus, steels and alloys, welding machinery and welded products were displayed for inspection. That industry appreciates the importance of keeping abreast of progress was indicated by the fact that before the exposition had closed much of the equipment was tagged as 'sold.' The 1928 National Metal Week must be pronounced unusually successful."

At the conclusion of Mr. Eisenman's report he read a letter received from Elmer A. Sperry, president of the American Society of Mechanical Engineers. The letter follows:

Mr. W. H. Eisenman, Secretary, September 6th, 1929
American Society for Steel Treating,
Cleveland, Ohio.

Dear Mr. Eisenman:

En route to the World Engineering Congress in Toyko, the President in office of the world's greatest engineering society, with some 36,000 members, is in New York on the identical dates of the meetings in Cleveland and cannot remain longer. It is incumbent on me to be here to do such honor as I have it in my power, and I am therefore required to change my plans to attend this meeting.

As President of the American Society of Mechanical Engineers and Chairman of the Engineering Division of the National Research Council it gives me pleasure to extend greetings to the American Society for Steel Treating.

You are setting the pace for all societies in America by your marvelous performance. I wish to compliment you on the wonderful virility of all your meetings and educational and informative exhibits, bringing together the master minds of America in your field of work. Nothing except peremptory demands on me that were unexpected at the time I accepted your kind invitation prevent my being present tonight.

Sincerly yours,
(Signed) Elmer A. Sperry,
President.

EAS:FG

REPORT OF THE TREASURER

J. M. Watson, *Treasurer*

The financial status of the Society has continued to improve in a sound and satisfactory manner since the last annual report submitted by the Treasurer in October of last year.

An unaudited profit and loss statement covering the period from January 1st to July 31st of this year and balance sheet as of July 31st give us the following figures.

The income of the Society for the first seven months of the year 1929 was:

	$107,393.82
And expenses for the same period were	99,871.04
Leaving an excess of income over expense of	$ 7,522.78

This excess has been derived from two sources—General Society Activities amounting to $3,126.83, and the Western States Metal and Machinery Exposition amounting to $4,395.95. This latter figure is especially pleasing to the Board of Directors, as the Los Angeles meeting was undertaken with the thought of showing the western coast the valuable work the A. S. S. T. is doing and some of the Board anticipated an excess of expense over income. It is a great compliment to our Secretary, Mr. Eisenman, that he can go into fields unknown and reap such a rich harvest, not only in a financial way but in building up good will and placing the Society in an enviable position.

The Balance Sheet shows the following:

Cash on hand and in banks	$ 48,988.31
Bond Investments	149,997.08
Accounts Receivable less allowance for Bad Debts	3,110.28
Inventory—Office Furniture—Travel Advances	11,923.66
Prepaid Convention Expense	13,298.05
	$227,317.38

A claim against these assets exists in the amount to be refunded to the chapters for dues received in July ....$	769.29
There is also included in the above accounts, the advance receipts for the present convention (Up to July 31)	42,943.75
As convention services have not yet been completed, a deduction should be made of this amount and the chapters' claims, totaling	43,713.04
The result will give the Society's Present Net Worth............	183,604.34

This figure represents a continued increase during the first seven months of this year, in the Society's Net Worth of 20%.

The financial report at the end of the present fiscal period, when convention activities are included, will undoubtedly again show a substantial increase in the net worth and total assets of the Society. As heretofore reported, the greater part of our increases have been due to the income derived from the expositions, but it is pleasing to note that our other activities also show an increase in excess income over expense.

The following table shows the total assets of the Society at the end of each year and the percentage of increase over the previous year.

		Assets	*% Increase*
Dec. 31, 1921		$ 16,520.90	00
Dec. 31, 1922		31,391.31	90
Dec. 31, 1923		46,821.30	49
Dec. 31, 1924		62,116.65	33
Dec. 31, 1925		87,196.60	40
Dec. 31, 1926		114,451.27	31
Dec. 31, 1927		158,396.88	38
Dec. 31, 1928	$204,736.92		
Less advance receipts from Western Metal Show	22,605.00	182,131.92	15
First seven months, 1929		183,604.34	?

After considerable investigation by the Finance Committee and by authority of the Board of Directors, $25,000.00 has been invested in additional high grade securities during the past year, as follows:

Associated Gas & Electric Co., 5½% Bonds	$10,000.00
Texas & Pacific Railroad Co., 5% Bonds	5,000.00
Procter & Gamble Co., 20 Year Debentures 4½%	10,000.00

The Society now has an exceptionally well balanced and diversified investment account consisting of bonds, all of which have an "A" rating or better. These investments are in Government Bonds—19.2%, Public and Semi-Public Utilities—32.5%, Railroad—9.9%, and unusually sound Industrials—18.5%. Geographically they include the area from Texas to Michigan to Massachusetts to New York.

Safe Keeping Account

This year, by recommendation of the Finance Committee and the authority of the Board, a safe keeping agreement has been entered into between the Society and the Cleveland Trust Co., whereby they hold all of our securities and reimburse us the first of each month the sum total of coupons clipped. This was thought advisable, as it was not always possible for the Treasurer and Secretary to go to the safe deposit box the first of every month and the bond interests could not be deposited immediately. It also relieves the Treas-

urer of a great personal responsibility and this is to be desired, for with a yearly turn over of approximately $250,000.00, the duties of the office are becoming exceedingly heavy and anything that can be done to lighten the loads safely, is a step in the right direction.

The Society is endeavoring to maintain this healthy financial condition and at the same time render to its members a maximum of service.

The bound Data Sheet Handbook which has met with universal approbation is now in process of its first revision. The financial outlay for this work has been light up to the present date, about $2,000.00 having been expended. It is estimated that an additional $6,000.00 will be spent on this activity before it is mailed to the members next June. Extension Division Lectures, Library and employment services are being extended to meet the needs and demands of our membership.

In order that the chapters may further carry out the aims and purposes of the Society and provide that personal touch and contact which the National Office is unable to do, a considerable portion of the gross dues received are returned to the chapters, that they may efficiently carry on this work.

A recapitulation of these chapter returns will be of interest.

		Gross Dues Received	*Returned to Chapters*	*% Returned*
Received in year	1921	$21,732.66	$ 7,244.22	33.3
	1922	27,714.64	10,051.95	36.3
	1923	30,598.03	12,751.45	41.6
	1924	34,871.83	14,194.14	40.7
	1925	40,161.35	16,039.63	39.9
	1926	49,047.18	20,185.83	41.2
	1927	54,221.87	22,390.43	41.3
	1928	59,684.84	25,351.17	42.5
First seven months	1929	40,642.70	17,813.55	43.8

The above record is unusual and accounts no doubt for the excellent programs and work which our local chapters carry on. A total of $358,675.10 has been received from January, 1921, through July, 1929, in payment of membership dues of all classes and $146,022.37, or 40.7%, has been returned to the chapters during this time. This high percentage of return enabled our chapters to report at the end of their fiscal year a combined net worth of close to $30,000.00. The individual net worths of the chapters varied considerably, of course, running from $100.00 to $5,000.00. In only four cases, however, does the net worth run close to $100.00, the rest being well over this sum.

Our present membership records show:

Members	4,801
Juniors	230
Sustaining	522
Honorary	20
Total	5,573

An analysis of the average amount received from all classes of members and expended in direct service to these members, taken from the audited report as of December 31, 1928, gives us the following results:

4,832 members paid total of	$ 59,684.84	
Average receipt per member		$12.35
Expenditures in direct service	131,780.92	
Average cost of service per member		27.27

Because the present financial condition of the Society as outlined in the foregoing report is sound and future prospects bright, it is to be expected that the aims and purposes of the Society will be carried on during the coming year with increased service and efficiency.

In conclusion, may I again express my thanks to my predecessors in office for their generous counsel and advice; to the members of the Finance Committee for their faithful attendance at meetings and their prompt investigation of securities submitted for purchase; to Mr. Carl Ohlson, the Assistant Treasurer, for his loyal attention to duty, and last, but by no means least, to Mr. Eisenman for his loyal cooperation and assistance at all times.

THE PRESIDENT'S ANNUAL ADDRESS

ZAY JEFFRIES, *President, 1929*

The secretary and treasurer have presented to you statistical, historical and financial information reflecting the health and growth of the American Society for Steel Treating. I have recently been looking over some of the earlier volumes of our TRANSACTIONS. In 1921 our first President, Professor A. E. White, made an annual report covering over six printed pages and our Secretary's report that year comprised only slightly more than one page. Professor White reported on most of the items which have been included in Mr. Eisenman's report this morning. I mention this to bring to your attention a change which has been gradually developing in the administration of our affairs. When the society was first organized the secretary was no more experienced than some of the other officers and many questions of policy were decided only after long deliberations of the board of directors and then often with the help of a report from one of the standing or special committees. The Society owes much to those members who gave so generously of their time and energy during a period when wise counsel was invaluable. Also the finances were such that gratuitous services were not only welcome but necessary.

During the past nine years our officers have changed from year to year, whereas our able secretary, W. H. Eisenman, has had the benefit of continuous and cumulative experience. The finances are healthy. The magnitude of the business has increased several fold. The inevitable result has been that the secretary has been called upon to shoulder more responsibility and the other officers less. The Society is much like a business of which the secretary is the general manager and the president the chairman of the Board of directors. The industrial analogy may be carried further. The wiser industrialists have learned by experience that certain kinds of competition are destructive. To combat destructive competition many co-operative associations have been formed with very beneficial results. Our Society has been anxious to co-operate with other societies and has extended invitations for joint and simultaneous meetings. The response to these invitations has demonstrated the desire of other societies to co-operate toward a common service to the metal industry.

The first Western Metal Congress which was held at Los Angeles in January, 1929, represented an epoch in society co-operation. Twelve societies

co-operated with ours, not only resulting in a very successful initial meeting, but assuring additional successful meetings on the West Coast in the future. The present National Metal Congress, which I believe to be the greatest metal meeting of history, would be impossible without the co-operation of the Iron and Steel Division and the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, the Iron and Steel Division of the American Society of Mechanical Engineers, and the American Welding Society. I think we may regard our leadership in intersociety co-operation as our greatest achievement to date. Also I think we can attribute the successes so far gained in this direction largely to the vision and cumulative experience of our secretary. Let us hope that such co-operation will be so continued that the Western Metal Congress and National Metal Congress and the Expositions will in the future assume increasing importance.

During the past year your officers have had no policy problems of a serious nature to decide. In fact the affairs have been so harmonious as to suggest that we have built on a solid foundation. It is true that several changes have been made and more are contemplated but every decision of the board of directors this year has been unanimous.

It now becomes my privilege to offer appreciation to those members who have so faithfully served the Society during the year. The officers and committees of the local chapters deserve especial congratulation. The whole is equal to the sum of its parts and the Society is equal to the sum of its members and most of these are in the chapters. It has been my pleasure to speak before members of eighteen of the chapters so far this year. Such interest and vigor as I encountered on my visits insure continued growth. In particular the Los Angeles Chapter is to be commended for its initiative in suggesting the Western Metal Congress and Western States Metal and Machinery Exposition. So well was their plan conceived and their work executed that I have decided to leave the R. M. Bird Bell in their custody for the coming year.

I wish also to compliment the Lehigh Valley, Philadelphia, New York, and Southern Tier Chapters and the New Jersey Group for their conception and execution of the joint meeting held at Bethlehem, Pennsylvania, on May 10, 1929. I would also compliment the Dayton, Cincinnati and Columbus Chapters for a similar joint meeting on March 18, 1929, at Dayton, Ohio. Also the joint meetings of the various chapters with local sections of other societies is a growing practice and is to be encouraged.

Our national office staff has performed with efficiency which can only result from internal harmony. Much of the smoothness of the administration of society affairs is the result of this happy family working toward the same objectives.

I wish also to express appreciation for the services of the members of the National Committees and others appointed for special services. It is realized that considerable personal sacrifice has been entailed in connection with their duties but it should be a source of gratification for them to behold their works.

Our indebtedness to the board of directors is acknowledged. Knowing

that few people hesitate to devote time and energy to enterprises which show beneficial results, I am confident that the board members feel amply repaid for their efforts. I can truthfully say that what little I have given to the Society is insignificant as compared with what I have received.

We should be much pleased with the relations between our Society and the trade journals. These publications have survived because they have best served industry and society. They must continue to serve in order to live. Their favorable reports and comments on the activities of our Society will, if unwarranted, jeopardize their own standing. On the other hand, if their comments are justified they not only help us but themselves also. I think we have ample evidence that the two groups have been mutually helpful.

Finally I wish the exhibitors to know that all of us appreciate the fine quality and high character of their exhibits. While the primary object of the Exposition is educational it is essentially a sales institution. Up to two years ago certain restrictions were put on salesmen members of the Society. The removal of these restrictions was a recognition by the Society that industry is endeavoring to operate all departments with one code of ethics. A corporation cannot escape the responsibility of an employees' untrue statement with the excuse that he is a salesman. Every employee is urged and expected to reflect the integrity of the organization which he represents. And so we find this year, to an extent never before realized, presidents and others in responsible positions in attendance at the booths. In many cases the individuals who present papers and enter into discussions at the technical sessions are also in attendance at the booths. The information given out at the booths will, in most cases, stand the spotlight of scientific criticism. Thus the latest technical developments are getting from the source to the public, with a minimum of distortion. The National Metal Exposition has won a place in connection with these meetings which can be filled in no other way. It is the worthy partner of the National Metal Congress.

In concluding may I make it clear that when we speak of success, health and growth of our Society, we regard our finances, the number of our members, the size of our exhibits, the amount of editorial matter and advertising in our publications, etc., only as reflections of the service which we are rendering to the metal and allied industries. The real and only measure of our contribution is the extent and quality of such service. Our past record is evidence that we are going approximately in the right direction. The road ahead, however, has many turnings and it will be necessary in the future as it has been in the past to make certain at each turn that the arrow points in the direction "Greater Service to Industry." With such a master guide continued growth is inevitable.

President Jeffries then presented to W. W. Farrar, who represented the Los Angeles Chapter of the Society, the president's bell and gavel, which was originally presented in 1926 to the Lehigh Valley Chapter by the then president, Robert M. Bird.

The next order of business was the report of the nominating

committee, which held its meeting on Monday morning. This report was made by the chairman of the National Nominating Committee, Earl C. Smith. The slate as selected by the nominating committee appears upon page 503 of this issue of TRANSACTIONS. After Mr.

DR. ALBERT SAUVEUR
Edward De Mille Campbell Lecturer for 1929

Smith's report had been submitted and accepted by the membership, President Jeffries introduced each of the men so nominated to the assembled members.

At the close of the annual business meeting, President Jeffries turned the meeting over to Professor Herbert M. Boylston, head of the department of Mining and Metallurgical Engineering at Case School of Applied Science, who served as chairman for the Edward De Mille Campbell Memorial Lecture which was presented by the dean of American metallurgists, Dr. Albert Sauveur of Harvard

University. More than six hundred members and guests of the Society were in attendance at this meeting. The subject of Dr. Sauveur's lecture was "Steel At Elevated Temperatures," which was discussed in a most interesting and informative way. This lecture will be published later.

The Wednesday afternoon technical session, under the chairmanship of Dr. Paul D. Merica, assisted by E. C. Bain as vice-chairman, consisted of a joint meeting of the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers and the American Society for Steel Treating. Five papers had been prepared and scheduled for this session. They are as follows:

2:00 P. M.—*Preparation of Microsections of Tungsten Carbide*—Dr. S. L. Hoyt, General Electric Co., Schenectady, N. Y.

Radiography as a Tool in the Metal Industry—W. L. Fink and R. S. Archer, Aluminum Company of America, Cleveland.

Effects of Cold Working on the Physical Properties of Metals—R. L. Templin, Aluminum Company of America, New Kensington, Pa.

A Method of Determining the Orientation of the Crystal in Rolled Metal from X-ray Patterns Taken by the Monochromatic Pinhole Method—W. P. Davey, C. C. Nitchie and M. L. Fuller, New Jersey Zinc Co., Palmerton, Pa.

Effect of Heat Treatment on Properties and Microstructure of Brittania Metal—B. Egeberg and H. B. Smith, International Silver Co., Meriden, Conn.

The first two papers were arranged for by the American Society for Steel Treating and last three by the Institute of Metals. Each of the papers was presented by its respective author and called forth much valuable and interesting discussion.

Thursday, September 12

The seventh session of the Convention was called to order at 10:00 o'clock by Chairman H. W. Gillett. Dr. Gillett was assisted by W. E. Ruder as vice-chairman. Four papers were scheduled for presentation at this session and were presented in the following order:

10:00 A. M.—*Hot Aqueous Solutions for the Quenching of Steels*—H. J. French, International Nickel Co., Bayonne, N. J., T. E. Hamill, U. S. Bureau of Standards, Washington, D. C.

10:40 A.M.—*A Study of the Iron-Chromium-Carbon Constitutional Diagram*—Dr. V. N. Krivobok, Carnegie Institute of Technology, and M. A. Grossmann, Central Alloy Steel Co., Canton, Ohio.

11:20 A. M.—*Non-destructive Testing*—E. A. Sperry, Sperry Development Company, Inc., Brooklyn, N. Y.

The Brittle Range in 18-8 Chromium-Nickel Iron (Presentation by title only)—H. H. Lester, Watertown Arsenal.

PROF. H. M. BOYLSTON
Chairman—Edward De Mille Campbell Lecture

The first two papers scheduled were presented by their respective authors, but in the case of Dr. Sperry's paper, Mr. H. C. Drake, chief engineer of the Sperry Development Company, presented the paper in Dr. Sperry's absence. The fourth paper, that of Dr. H. H. Lester, was presented by title only.

Dr. O. E. Harder of the University of Minnesota, assisted by J. S. Vanick, presided at the Thursday afternoon session which opened at 2:00 P. M. The four papers scheduled for presentation at this meeting were as follows:

2:00 P. M.—*Graphitization of Pre-quenched White Cast Iron*—H. A. Schwartz, H. H. Johnson and C. H. Junge, National Malleable and Steel Castings Co., Cleveland.
2:25 P. M.—*Austenite and Its Decomposition*—Albert Sauveur, Harvard University, Cambridge, Mass.
3:00 P. M.—*High Strength Cast Iron*—E. J. Lowry, Detroit.
3:30 P. M.—*Crystal Structure of an Iron Phosphide*—James B. Friauf, Carnegie Institute of Technology, Pittsburgh.

These papers were all presented by their respective authors, and as in the case of all of the papers which had been presented at each of the sessions of the week, the papers at this session were thoroughly discussed, both in written and oral form.

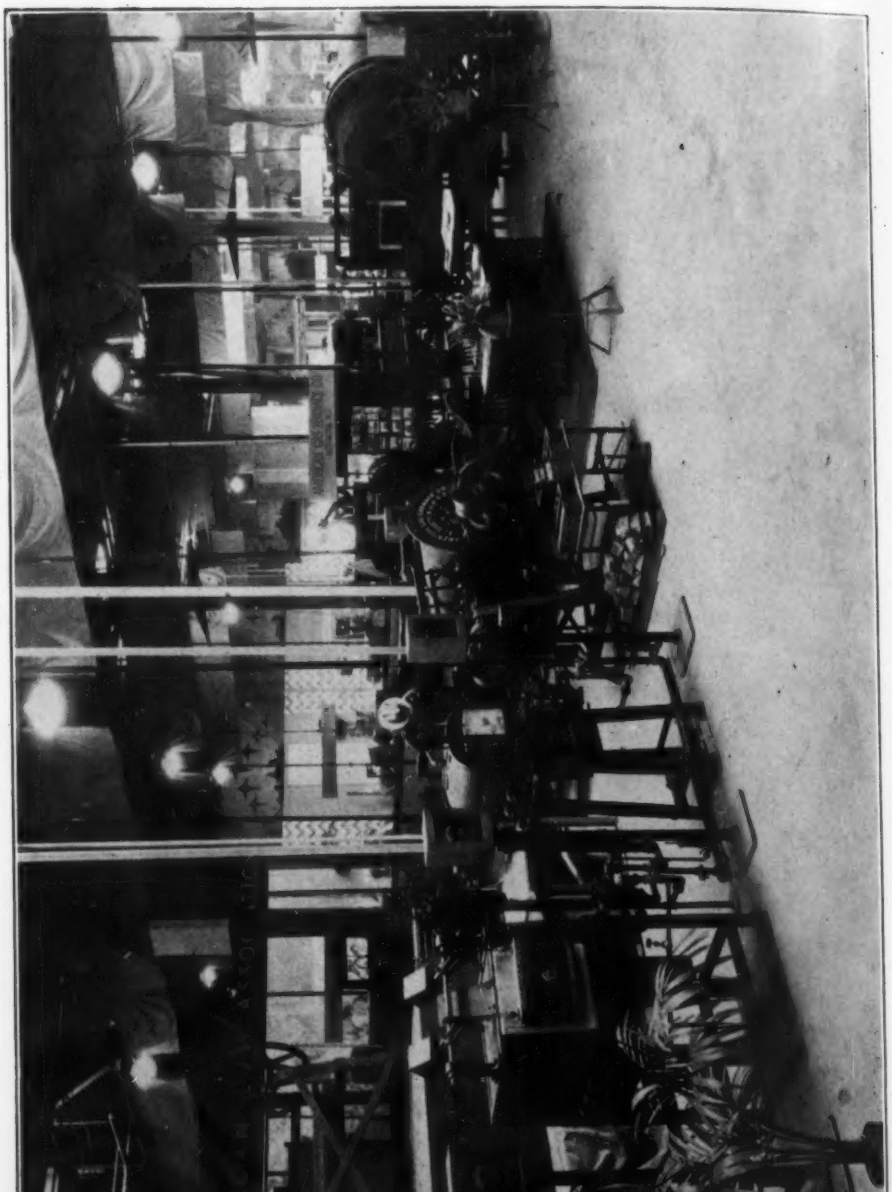
Annual Banquet

In accordance with the custom which has been established by the society, the annual banquet was held Thursday evening in the ballroom of the Cleveland Hotel. About 400 members and guests were present at this annual function and following an excellent dinner, the guests were entertained by a well-executed musical

DR. CARL R. WOHRMAN
Howe Medalist for 1929

program. The past officers, honorary members and guests who were seated at the speakers' table were as follows: W. H. White, W. W. Macon, F. T. Sisco, W. P. Woodside, J. A. Mathews, R. G. Guthrie, S. Skowronski, F. G. Hughes, Harvey Firestone, Sr., Zay Jeffries, Wm. E. Wickenden, Albert Sauveur, J. M. Watson, G. B. Waterhouse, T. E. Barker, Arthur G. McKee, A. H. d'Arcambal, W. H. Phillips, H. J. Twelvetree, and W. H. Eisenman.

Dr. Jeffries, as toastmaster, first called upon W. H. Eisenman, who in turn presented Colonel H. J. Twelvetree with a loving-cup as a token of the recognition of the American Society for Steel Treating for the excellent cooperation of the entire Auditorium staff during the National Metal Congress and Exposition. This cup is especially suitable for presentation by the Steel Treaters,



GENERAL VIEW OF GAS SECTION

being made of stainless steel by a German organization, dies being used which are not available in the United States. Colonel Twelvetree made a short speech of acknowledgment.

The past president's medal was then presented to Mr. Frederick G. Hughes by Dr. Jeffries and duly acknowledged.

Following this, Dr. Jeffries presented to Dr. Albert Sauveur the Howe Medal. The Howe Medal award for 1929 was made to Dr. Carl R. Wohrman for his paper entitled, "Inclusions in Iron," which, in the judgment of the awards committee, was considered the paper of highest merit published in the TRANSACTIONS of the Society for the year. Due to the fact that Dr. Wohrman is at present absent in Europe, Dr. Sauveur, who had been one of his instructors in his student days, accepted the medal in his stead.

Dr. Sauveur is quoted as follows:

"In accepting the Howe Medal on behalf of Dr. Carl R. Wohrman, I feel keenly the satisfaction of the teacher and his justifiable pride when conscious of the proficiency and success of one of his students.

"A short biographical sketch of your medallist may be of interest.

"Wohrman was born in Estonia in 1897. During the world war he served as an officer in the Russian Army and later in the Estonian Army, covering the period of 1916 to 1918.

"After spending one year in the Mining Academy of Petrograd, he came to Harvard University where he remained six years. In 1924 he received the degree of Bachelor of Science, Summa Cum Laude, the only one in the Engineering School to attain so high a distinction. His scholastic record, sixteen A's and one B, has, I believe, never been surpassed. He was from 1921 to 1924 at the head of his class. In 1925 he was awarded the degree of Mining Engineer and in 1927 he obtained the degree of Doctor of Science in Metallurgy. He was then awarded a scholarship by the National Research Council and went to Jena, Germany, to devote one year to the study of optics, a subject in which he was deeply interested. Returning to the United States, he joined the research staff of the Bell Telephone Laboratories, where he was warmly welcomed by our friend, F. F. Lucas.

"Dr. Wohrman's wife, however, had been in poor health for several years and she remained in a sanitarium in Switzerland. Her condition grew worse and Wohrman decided to return to her. The Western Electric Company very generously made it possible for him to remain in their employ while in Europe. A few months ago, Mrs. Wohrman died. It is a sad thought that she did not live to witness the distinction her husband is receiving today. It has been my privilege to know Mrs. Wohrman, and it is with a feeling of admiration and of respect that I speak of her here, for she was a woman of rare attainments and of exquisite feelings.

"The contribution for which you are awarding to Dr. Wohrman the Howe Medal, namely, 'Inclusions in Iron and Steel', embodies the results of an

extensive research covering a period of two years and conducted in the Metallurgical Laboratory of Harvard University as part of the requirements for the degree of Doctor of Science in Metallurgy. I believe it to be a landmark in that important field to which future workers will frequently refer.

"I cannot refrain from recalling that this paper was declined by an important engineering society, not for lack of merit, but because of the cost of publication. It is fortunate that we have with us the American Society for Steel Treating, which through clear vision, courage and good judgment, is so efficiently serving the profession. The appreciation of the profession is reflected in our increasing membership and vigorous growth.

"I have received this afternoon a cable from Dr. Wohrman, which reads as follows:

"'Geneva, Switzerland. September 12, 1929.

News of the Howe Medal award received. Thank you for accepting award. Please transmit to the American Society for Steel Treating my great appreciation of the honor conferred and sincere wishes for continued fruitful activity in the great metallurgy field. Kindest regards all friends.

Wohrman.'"

Honorary membership was this year bestowed upon Thomas Alva Edison. As Mr. Edison was at that time recovering from a serious attack of bronchial pneumonia, Harvey Firestone, Sr., president of the Firestone Tire and Rubber Company of Akron, accepted the honor for Mr. Edison. Mr. Firestone, in his informal acceptance speech, gave some very interesting reminiscences of the camping trips of Mr. Edison, Mr. Ford, Mr. Burroughs and himself, as well as some intimate glimpses of the real personality known as Thomas Alva Edison.

Representatives of the various participating societies in the National Metal Congress, with the exception of the American Welding Society, who was holding its own banquet at the Hotel Statler on the same evening, were seated at the speakers' table and were introduced by Dr. Jeffries to the guests. They were, S. Skowronski, chairman, Institute of Metals Division, and G. B. Waterhouse, chairman Iron and Steel Division, American Institute of Mining and Metallurgical Engineers, and W. W. Macon, executive committee, Iron and Steel Division, American Society of Mechanical Engineers.

Dr. William E. Wickenden, who just assumed the presidency of Case School of Applied Science, was the principal speaker of the evening. His subject was "An Epoch in the Making," a plea for coordinated systematic research. A brief abstract follows.

Some men are so significant that they mark an epoch; an era of history closes when they pass to their reward. Will we see another Edison? Probably not. To get perspective on his life and times we must go back to times before the idea of progress was invented. Mediaeval Europe, living on ideas borrowed from the ancients, fell into static ways. Man cared more for preserving than for improving traditional ways. The free labor of the guilds was more fertile than the slave labor of the ancients. In it a revolutionary idea germinated, that tools and processes could be made better by deliberate effort without waiting for slow evolution.

The century beginning with Watt's engine in 1767 was the most amazing in in all industrial history. Its pioneers were nearly all working men, trained by apprenticeship and self-taught in rudimentary science. Their work was so brilliant that men came to have almost boundless confidence in trial and error process of experiment and invention. This tradition was Edison's inheritance and he its most brilliant exemplar.

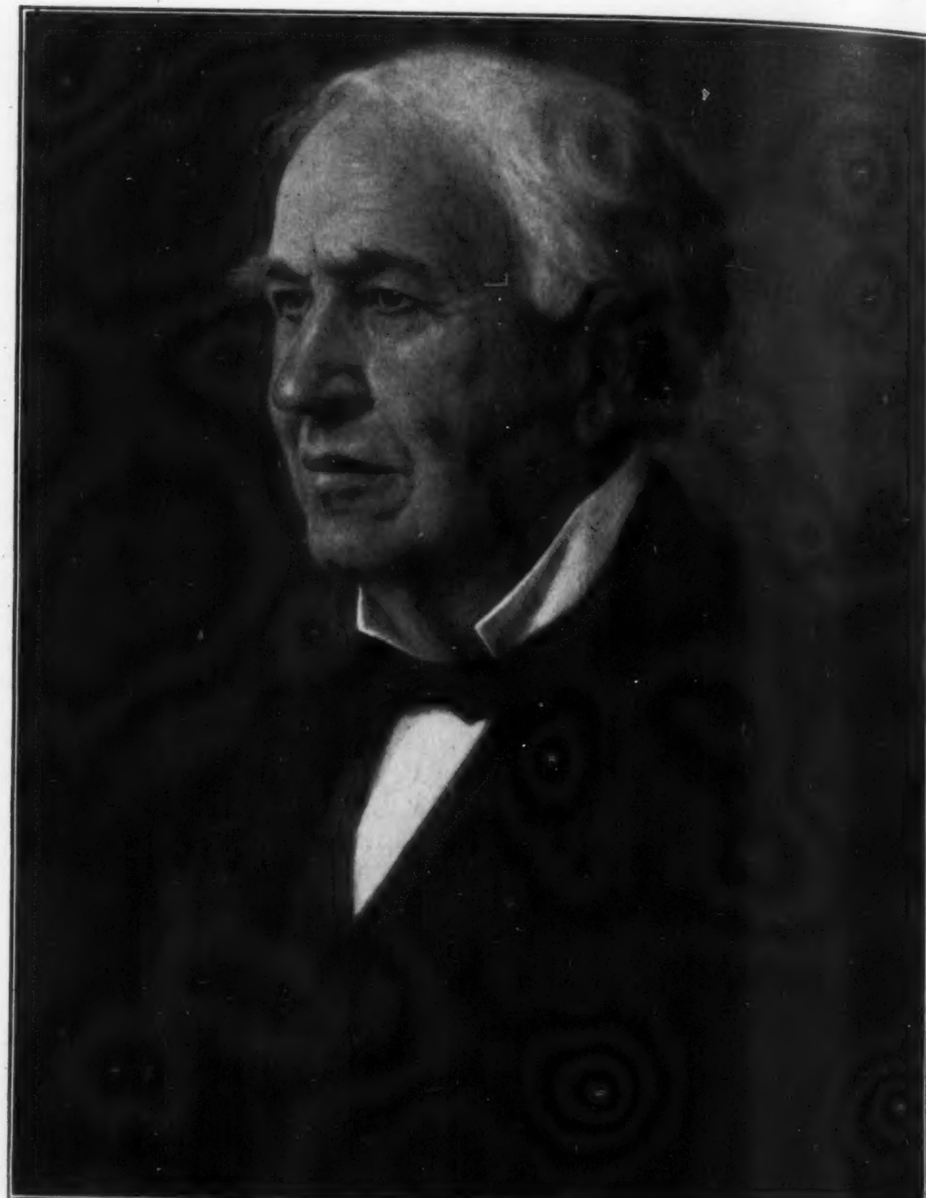
In a few months we are to celebrate the semi-centennial of the incandescent lamp. Edison did not invent the lamp, the basic ideas were old; but he reduced them to commercial practicality with prodigious experimental labor and resourcefulness. As Edison himself described his method:

"Through all those years of experimenting and research I never once made a discovery. All my work was deductive, and the results I achieved were those of invention pure and simple. I would construct a theory and work on it until I found it untenable, then it would be discarded at once and another theory evolved. This was the only possible way for me to work out the problem."

In one aspect of his work on the lamp alone, the search for the best vegetable fibre to carbonize into a filament, he spent over $100,000, sent searchers into every corner of the globe and himself performed over 6000 experiments.

Edison's experience with the lamp is the very climax of efforts at technical progress through direct grappling with Nature and compelling her to yield her secrets by sheer persistence of trial, error and elimination. The price of progress would be staggering if it had all to be won this way. Happily, there is a more excellent way. Difficult as Nature is to conquer by direct, deductive attack, she yields with shy reticence to the wooing of the inquiring mind. The way to her heart is by induction. This is the new strategy of progress, to woo Nature by inquiry rather than to wrestle with her.

In the old order of events the technical arts grew out of discovery and science followed after—usually long after—with her higher refinements. Two great modern industries have grown by reversing this order, the chemical and the electrical. The new plan has been found immensely fertile and time-saving. Thirty years after Faraday worked out the principle of electro-magnetic induction Paccinoti had his dynamo running, while less than ten years separated J. J. Thompson's work on the electrical conduction of gases and Fleming's vacuum tube valve. Three years later De Forest added the third element on which the radio art has been built. Contrast this record with the 150 years which elasped between Newcomer's engine and the study of the essential conditions of its efficiency by Carnot and Rankine and you have the case in a nutshell.



THOMAS ALVA EDISON

The new strategy of progress is the substitution of the orderly attack of the research laboratory for our old dependence on sporadic invention. As one modern philosopher says:

"The greatest invention of the nineteenth century was the invention of the method of invention . . . That is the real novelty which has broken up the foundations of the old civilization."

The conditions of survival in industry are changing with startling swift-

ness. Power and machinery, with the higher efficiency of our workmen have put production up one-third to one-half. The battle for markets is raging everywhere. Being a successful business man has become about as hard a job as sticking to a college presidency. A new competition has sprung up—competition between industries rather than firms or individuals. It is lacquer against paint; rayon against cotton; cigarettes against sweets. Where is the good bread that mother used to bake? It is said that 7200 flour mills were forced out in a decade because mother changed her mind.

The time has passed when advertising alone will get and sustain sales. The real salesmen of today are a better product and a cheaper way of making it. Research opens the secrets to both.

There is a striking parallel between our day and the dramatic story of Belshazzar and his feast. Amid the scene of opulence and splendor a hand appeared, writing on the wall. The hand has reappeared for many an industry. It writes: "The price of progress and survival is research."

Of especial interest were the sessions held morning and afternoon on Friday, September 13, which constituted the International Nitriding Symposium. Dr. G. B. Waterhouse presided, assisted by H. J. French as vice-chairman. Dr. Adolph Fry, Krupp A. G., Essen, Germany, and Pierre F. M. Aubert of Paris, France, served as honorary vice-chairmen, and a short talk was given by Mr. C. K. Everett of the Edgar Allen Steel Company, Sheffield, England. Four papers upon the subject of Nitriding were presented at the morning session, with an additional address by Dr. Adolph Fry. The papers were presented in the following order by their respective authors:

9:30 A. M.—*The White Layer in Gun Tubes*—H. H. Lester, Watertown Arsenal, Watertown, Mass.

Observations Upon the Iron-Nitrogen System—Samuel Epstein, Illinois Steel Co., So. Chicago, Ill.

A Study of the Nitriding Process—V. O. Homerberg, and J. P. Walsted, Massachusetts Institute of Technology, Cambridge, Mass.

Researches on Nitriding Steels—Dr. O. E. Harder, University of Minnesota, Minneapolis, Minn., J. T. Gow and L. A. Willey, co-authors.

The afternoon session on Friday formed a second part of the Nitriding Symposium and was also the tenth and final technical session of the Convention. It was held in the ballroom of the Public Auditorium at 2:00 P. M., the same men acting as chairman and vice-chairmen as at the morning session. The order of the presentation of papers was somewhat changed from the schedule, Mr. McQuaid presenting his paper, written jointly with W. J.

A GENERAL VIEW IN THE ANNEX

Ketcham, immediately following that of Mr. Sergeson. The balance of the papers were presented in the scheduled order.

1:30 P. M.—*Investigations in Nitriding*—Robert Sergeson, Central Alloy Steel Corp., Canton, Ohio.

Short Time Nitriding of Steels in Molten Cyanides—A. B. Kinzel, and J. J. Egan, Union Carbide and Carbon Research Laboratories, Long Island City, N. Y.

A Few Practical Fundamentals of the Nitriding Process—H. W. McQuaid and W. J. Ketcham, Timken-Detroit Axle Co., Detroit.

The Use of Nitrided Steel in High Temperature-High Pressure Steam Service—V. T. Malcolm, Chapman Valve Manufacturing Co., Indian Orchard, Mass.

Much interesting and valuable discussion followed the presentation of the papers. Dr. Waterhouse, immediately following the presentation of the first two papers for the afternoon, called for discussion upon the morning papers and the two already presented. The nine papers included in the Nitriding Symposium, together with the discussion which followed their presentation, will be published as a special edition of TRANSACTIONS, upon which the editorial department is now working, and which, it is hoped, will be ready for distribution to the entire membership of the society by October 15th.

Plant Inspection

The committee on arrangements had provided an interesting program of plant inspection and approximately 1000 members and guests of the five participating societies visited the various organizations which opened their plants for inspection. The following plants were visited:

National Tool Company, Lamson and Sessions Company, Otis Steel Company, Case School of Applied Science, Burdett Oxygen, Jos. T. Ryerson & Sons, Lincoln Electric Company, Eaton Axle and Spring Company, Warner and Swasey Company, Industrial Brownhoist Corporation, White Motor Company, Columbia Axle Company, Lakeside Steel Improvement Company, American Steel and Wire Company, Vlchek Tool Company, Gears and Forgings, Inc., Ferro Machine and Foundry Company, National Malleable and Steel Castings Co., National Acme Company, Hupp Motor Car Company, Great Lakes Aircraft Corporation, the Cleveland Tractor Company and the W. S. Bidle Company.

About 250 persons boarded the train, furnished through the courtesy of J. A. Appleton, general superintendent, Cleveland, of

the Pennsylvania Railroad, at 8:30 A. M., on Thursday morning, and visited the Cleveland and Pittsburgh Ore Docks at Whiskey Island. Because of the severe wind storm of the night before only one ore boat was available upon the entire great lakes, but the M. A. Hanna Company managed to secure it in order that the members and guests of the society might have the opportunity of seeing an ore boat in the process of loading and unloading.

Ladies' Entertainment

Approximately 200 visiting ladies and their guests were entertained at luncheon and bridge, automobile sight-seeing trips, shopping tours and theater parties during the week of the National Metal Congress.

American Welding Society

The American Welding Society, meeting simultaneously with the American Society for Steel Treating, held their technical sessions in both the Hotel Statler and the Public Auditorium. A very interesting group of papers was presented at the various sessions, titles and authors of which are published herewith:

Monday, September 9—Afternoon Session

Hotel Statler

2:00 P. M.—Meeting of Board of Directors, American Welding Society.

Tuesday, September 10—Morning Session

Hotel Statler

10:00 A. M.—*Business Meeting*—F. T. Llewellyn, president, presiding.

Technical Session

A. E. Gaynor, vice-president, presiding

10:30 A. M. *The Effect on Design of the Use of Welding in the Manufacture of Electric Machinery*—H. G. Reist, General Electric Company, Schenectady, N. Y.

Cutting and Welding Steel Parts to Replace Castings—W. F. Buchanan, Bessemer Gas Engine Company.

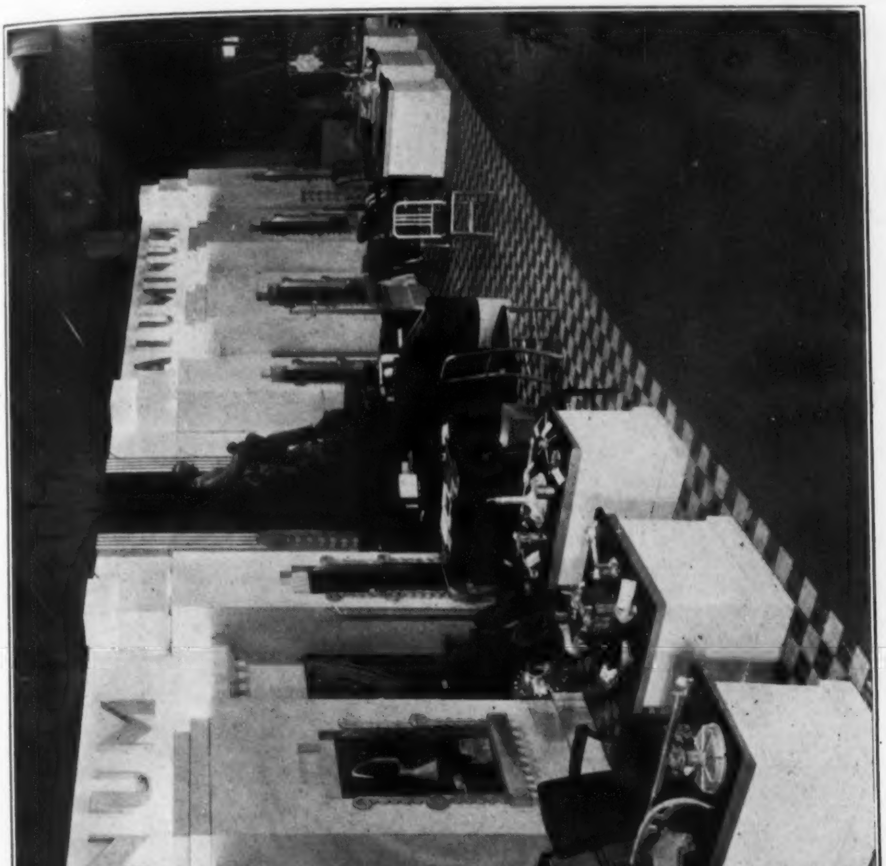
Afternoon Session

Public Auditorium, Club Room A

H. L. Whittemore, Bureau of Standards, presiding.

2:00 P. M.—*Welding of Copper and Copper Alloys*—I. T. Hook, American Brass Co.

How to Test Welds—F. G. Tatnall, Southwark Foundry and Machine Co.



THE ALUMINUM EXHIBIT

EVENING SESSION

Cleveland Hotel

9:00 P. M.—National Metal Congress Dance.

WEDNESDAY, SEPTEMBER 11—MORNING SESSION

8:30 A. M.—Starting from Hotel Statler, Inspection tour of three plants.

10:00 A. M.—Hotel Statler, Conference of research workers on fundamentals of welding, H. M. Hobart, Chairman, presiding.

AFTERNOON SESSION

Public Auditorium, Club Room A

J. J. Crowe, Air Reduction Sales Company, presiding.

2:00 P. M.—*Study of Nitride Needles*—P. Alexander, General Electric Company, Schenectady, N. Y.

Chemical Reactions of the Carbon Arc—G. E. Doan and E. Ekholm, Lehigh University.

A Metallographic Study of Some Metal Arc Welds—H. M. Boylston, Case School of Applied Science, Cleveland.

EVENING SESSION

Hotel Statler

J. H. Edwards, chairman, presiding.

7:30 P. M.—Meeting of Structural Steel Welding Committee.

THURSDAY, SEPTEMBER 12—MORNING SESSION

Hotel Statler

President F. T. Llewellyn, presiding.

10:00 A. M.—*Non-destructive Testing of Welds with the Stethoscope and X-ray*—C. O. Burgess, A. B. Kinzel and A. R. Lytle, Union Carbide and Carbon Research Laboratories, Inc., Long Island City, N. Y.

Welding Studies at the Watertown Arsenal—Major J. B. Rose, Ordnance Department, U. S. A., Watertown, Mass.

Stress Strain Characteristics of Welded Joints—J. H. Smith, University of Pittsburgh, Pittsburgh.

AFTERNOON SESSION

Public Auditorium, Club Room A

Joint Technical Session with A. S. M. E.

C. A. Adams, presiding.

2:30 P. M.—*Foreign Practice in Welding of Boiler Tubes and Drums*—G. A. Orrok, New York City.

Automatic Arc Welding of Thin Sheets—W. L. Warner, General Electric Company, Schenectady, N. Y.

Non-destructive Tests of Welds—Elmer A. Sperry, Sperry Development Company, Brooklyn, N. Y.

FRIDAY, SEPTEMBER 13—MORNING SESSION

Hotel Statler

J. C. Lincoln, Lincoln Engineering Company, presiding.

10:00 A. M.—*Oxyacetylene Welding of Pipe Lines in the Field*—W. R. Ost, Air Reduction Sales Co., New York City.

Electric Welding of Field Joints of Oil and Gas Pipe Lines—H. C. Price, Welding Engineering Company.
Welding of Tubing and Pipes for Locomotives and Boilers—H. A. Woofter, Swift Electric Welder Company.

AFTERNOON SESSION
Hotel Statler
C. A. Adams, presiding.

2:00 P. M.—Meeting of American Bureau of Welding.

The annual banquet and dance of the American Welding Society was held on Thursday evening in the ballroom of the Hotel Statler.

INSTITUTE OF METALS DIVISION

IRON AND STEEL DIVISION, AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

The Institute of Metals Division and the Iron and Steel Division of the American Institute of Mining and Metallurgical Engineers held their fall meetings concurrently with the American Society for Steel Treating. Their headquarters were in the Hotel Cleveland and their morning technical sessions were held in this hotel and the afternoon meetings in the Public Auditorium. Their respective programs were as follows:

INSTITUTE OF METALS

TUESDAY, SEPTEMBER 10—MORNING SESSION
Hotel Cleveland

Secondary Metal Symposium—T. A. Wright, Chairman; E. R. Darby, Vice-Chairman.

10:00 A. M.—*Manufacture of Wire Bars from Secondary Copper*—J. W. Scott and W. A. Scheuch, Western Electric Co., Hawthorne Station, Chicago.
Metal Recoveries in Secondary Aluminum Practice—R. J. Anderson, Fairmont Mfg. Co., Fairmont, W. Va.
Reclaiming Nonferrous Scrap Metals at Manufacturing Plants—F. N. Flynn, metallurgist, Milwaukee.
Utilization of Secondary Metals in the Red Brass Industry—H. M. St. John, Detroit Lubricator Co., Detroit.
Recovery of Waste from Tin-base Babbitting Operations—P. J. Potter, Federal Mogul Corporation.
Correlation of the Ultimate Structure of Hard Drawn Copper Wire with the Electrical Conductivity—R. W. Drier and C. T. Eddy.

6:30 P. M.—Joint Dinner, Institute of Metals and Iron and Steel Division.
Speakers—Floyd T. Taylor, vice-president, Hanson, Van Winkle, Munning Company.
Dr. H. W. Gillett, Director, Battelle Memorial Institute.

WEDNESDAY, SEPTEMBER 11—MORNING SESSION

10:30 A. M.—A. S. S. T. *E. D. Campbell Memorial Lecture*—Dr. Albert Sauveur.

AFTERNOON SESSION

Joint Meeting of Institute of Metals Division and American Society for Steel Treating. Meeting Room, Public Auditorium—Club Room B

P. D. Merica, Chairman
E. C. Bain, Vice-Chairman

2:00 P. M.—*Effects of Cold Working on the Physical Properties of Metals*—R. L. Templin, Aluminum Company of America, New Kensington, Pa.

Determining Orientation of Crystals in Rolled Metal from X-ray Patterns Taken by the Monochromatic Pin-Hole Method—W. P. Davey, C. C. Nitchie and M. L. Fuller, New Jersey Zinc Co., Palmerton, Pa.

Preparation of Microsections of Tungsten Carbide—Dr. S. L. Hoyt, General Electric Co., Schenectady, N. Y.

Radiography as a Tool in the Metal Industry—W. L. Fink and R. S. Archer, Aluminum Company of America, Cleveland.

Effect of Heat Treatment on Properties and Microstructure of Brittania Metal—B. Egeberg and H. B. Smith, International Silver Co., Meriden, Conn.

THURSDAY, SEPTEMBER 12—MORNING SESSION

Hotel Cleveland

S. L. Hoyt, Chairman
E. M. Wise, Vice-Chairman

10:00 A. M.—*Metallography of Commercial Thorium*—Edmund S. Davenport, Westinghouse Lamp Works, Bloomfield, N. J.

The Causes of Cuppy Wire—W. E. Remmers, Western Electric Co., Hawthorne Station, Chicago.

The Effect of Alloying on the Permissible Fiber Stress in Corrugated Zinc Roofing—E. A. Anderson, New Jersey Zinc Co., Palmerton, Pa.

The System Cadmium-mercury—R. F. Mehl and C. S. Barrett, Naval Research Laboratory, Anacostia, D. C.

An Investigation to Determine the Eutectic Composition of Copper and Tin—G. O. Hiers and G. P. deForest, Research Laboratory, National Lead Co., Brooklyn, N. Y.

Notes on the Crystal Structure of the Alpha Copper-tin Alloys—R. F. Mehl and C. S. Barrett, Naval Research Laboratory, Anacostia, D. C.

Deoxidation of Copper with Calcium and Properties of Some Copper-calcium Alloys—E. E. Schumacher, W. C. Ellis and J. F. Eckel.

1:30 P. M.—Plant Inspection, Nela Park.

IRON AND STEEL DIVISION

TUESDAY, SEPTEMBER 10—AFTERNOON SESSION—2:00 P. M.

Public Auditorium, Club Room C
A. L. Feild, Chairman

The Change in Microstructure of Iron at the A_3 Transformation Point—B. A. Rogers, Western Electric Company, Chicago.

A New Development in Wrought Iron Manufacture—James Aston, Carnegie Institute of Technology, Pittsburgh.

Blast Furnace Filling and Size Segregation—C. C. Furnas and T. L. Joseph.

WEDNESDAY, SEPTEMBER 11—MORNING SESSION—10:00 A. M.

Hotel Cleveland
C. B. Murray, Chairman

Fluorspar and Its Uses—Earl Brokenshire, Oglebay, Norton and Company Cleveland.
Foreign Iron Ores—Charles Hart, Delaware River Steel Co., Chester, Pa.
Iron-ore Sinter—G. M. Schwartz, University of Minnesota, Minneapolis, Minn.
The Bradley Process for the Beneficiation of Manganiferous Ores—Carl Zapffe, Northern Pacific Railroad, Brainerd, Minn.

THURSDAY, SEPTEMBER 12—AFTERNOON SESSION—2:00 P. M.

Public Auditorium, Club Room C
G. B. Waterhouse, Chairman

The Diffusion of Iron Oxide from Slag to Metal in the Open-hearth Process—C. H. Herty, Jr., U. S. Bureau of Mines, Pittsburgh.
Experimental Data on the Equilibrium of the System Iron Oxide-carbon in Molten Iron—A. B. Kinzel and J. J. Egan, Union Carbide and Carbon Research Laboratories, Long Island City, N. Y.
Rate of Carbon Drop and Degree of Oxidation of the Metal Bath in Basic Open-hearth Practice, II.—A. L. Feild, Union Carbide and Carbon Company, New York City.

On Tuesday evening these two divisions held their annual fall meeting banquet in the ballroom of the Hotel Cleveland, which was attended by over one hundred members and guests.

IRON AND STEEL DIVISION
AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The Iron and Steel Division of the American Society of Mechanical Engineers held its fall meeting in conjunction with the other four societies during the National Metal Congress. Their headquarters were at the Hotel Hollenden, where their morning technical sessions were held, while the afternoon meetings were held in the Public Auditorium. A list of the papers presented, together with their respective authors, follows:

WEDNESDAY, SEPTEMBER 11—AFTERNOON SESSION

Public Auditorium, Club Room C
C. S. Robinson, Chairman

2:00 P. M.—*Developments in Blast Furnace Design and Practice*—Arthur G. McKee, Cleveland.
Ore Handling Bridges—Alexander C. Brown, Industrial Brown Hoist Corp., Cleveland.
Oil Electric Locomotives in Steel Mill Transportation—W. L. Garrison, Ingersoll-Rand Co., New York City.

THURSDAY, SEPTEMBER 12—AFTERNOON SESSION

Public Auditorium, Club Room A
Joint Session with American Welding Society

F. M. Farmer, Chairman

2:00 P. M.—*Non-destructive Tests of Welds*—Elmer A. Sperry, Sperry Development Co., Brooklyn, N. Y., and President of American Society of Mechanical Engineers.

Foreign Practice in Welding Boiler Tubes and Drums—George A. Orrok, Consulting Engineer, New York City.

Automatic Arc Welding of Thin Sheets—W. L. Warner, General Electric Company, Schenectady, N. Y.

FRIDAY, SEPTEMBER 13—MORNING SESSION

Hollenden Hotel

G. T. Snyder, Chairman

10:00 P. M.—*Alloy Steels in Iron and Steel Mill Equipment*—O. Bamerger and E. R. Johnson, Central Alloy Steel Corp., Massillon, Ohio.

Evolution of Drives for Mill Table Rollers—K. W. Feller, Schloemann Engineering Corp., Pittsburgh.

AFTERNOON SESSION

Public Auditorium, Club Room A

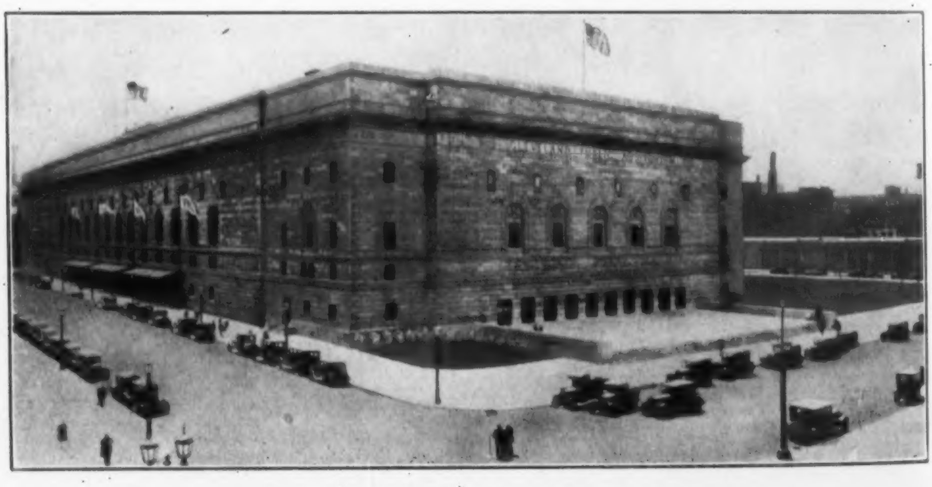
Joint Meeting with A. S. S. T.

H. A. Schwartz, Chairman

2:00 P. M.—*Distribution of Heat in Combustion Furnaces*—M. H. Mawhinney, Electric Furnace Co., Salem, Ohio.

Advantages of Producer Gas as a Fuel Compared with Other Forms of Fuel—Victor Windett, Wellman, Seaver, Morgan Co., Cleveland.

Powdered Coal Cupola—D. H. Meloche, American Radiator Co., New York City.



CLEVELAND PUBLIC AUDITORIUM

RADIOGRAPHY AS A TOOL IN THE METAL INDUSTRY

By W. L. Fink and R. S. Archer

Abstract

Radiography has now been successfully employed in regular commercial operation for nearly two years at the Cleveland plants of the United States Aluminum Company. In this paper there are given typical examples of the applications which have been made of the radiographic method in this laboratory. The cost of these radiographs is given and the field of profitable application of the method is discussed. There are also brief descriptions of methods and apparatus. A comprehensive bibliography is appended.

DURING the last fifteen years there have been numerous investigations in the field of metal radiography. Reports of these investigations have indicated that radiography is very useful in the examination of metal products. Certain government and educational institutions as well as certain manufacturers of X-ray equipment have employed radiography in the examination of metal parts. It was not until very recently, however, that any of the manufacturers of metal products in the United States installed radiographic equipment.

After considering for some time whether this method of investigation would be practical from a commercial standpoint, it was decided about two years ago to install radiographic equipment as a regular adjunct to the production plants of the United States Aluminum Company at Cleveland which are engaged in the manufacture of sand castings, permanent mold castings, die castings, and forgings of aluminum and magnesium. The results obtained have been considered of sufficient value to justify the installation of an X-ray laboratory at the company's new foundry in Fairfield, Connecticut.

It is the chief purpose of this paper to show how the initial X-ray equipment has been used to advantage. To interpret intelligently the features seen in radiographs, it was frequently necessary to correlate these features with evidence obtained by other methods such as ma-

A paper presented before the Eleventh Annual Convention of the society, Cleveland, September 9 to 13, 1929. The authors, W. L. Fink and R. S. Archer, members of the society, are associated with the research bureau of the Aluminum Company of America, Cleveland. Manuscript received June 10, 1929.

chining, fracturing, microscopic examination, mechanical tests, etc. A brief account of the method of making radiographs includes well known facts and methods together with new information regarding exposure times and certain special methods.

Radiographic Methods

The general principles underlying radiography are well known. X-rays travel in straight lines like light and have the property of penetrating matter which is opaque to ordinary light. The absorption coefficient of X-rays is roughly proportional to the density of the material through which they pass.[1] This makes it possible to locate inclusions whose densities differ materially from that of the surrounding medium.

X-rays are commonly detected by the use of a photographic film or fluorescent screen.[2] An example of the first method is found in the familiar dental radiographs. X-rays darken the film so that regions of low density which permit more X-rays to pass appear dark on the negative in comparison with regions of high density. Thus cavities in teeth or voids or gas inclusions in metal specimens appear as dark spots on a radiograph. X-rays illuminate the fluorescent screen so the reverse effect is obtained. In the familiar practice of examining the human body with the assistance of the fluoroscope, dense structures such as bone appear dark.

The fluorescent screen has advantages in speed and economy but its use in metal radiography is limited by several considerations. In the first place, since the effect is almost instantaneous, the screen does not have the power of integrating X-ray energy as a film emulsion does, so it is necessary to have much greater quantities of X-ray energy pass through the specimen. This naturally limits the thickness of material that can be penetrated. Secondly, the sensitivity of the fluoroscope method is much less than that of the photographic method. The actual ratio of sensitivity varies from one case to another, but in general it may be said that the photographic method is from 5 to 30 times as sensitive as the fluoroscopic method. Another consideration is that the fluoroscope does not provide the permanent record which is

[1]A more accurate statement is that the absorption coefficient of X-rays increases with the atomic number of the absorbing atoms, the number of atoms per unit volume, and the wave length of the X-rays.

[2]X-Rays may also be detected by their ionizing effects, and this method may be applied in special cases to the examination of metal objects.

provided by photography and which is often desired. Finally, there are certain elements of danger involved in the exposure of the human body to X-rays. It is easy to avoid such exposure in taking photographs, but not so simple when the fluoroscope is used.

There are undoubtedly certain cases where the fluoroscopic method will be desirable. This might be the case, for example, in the

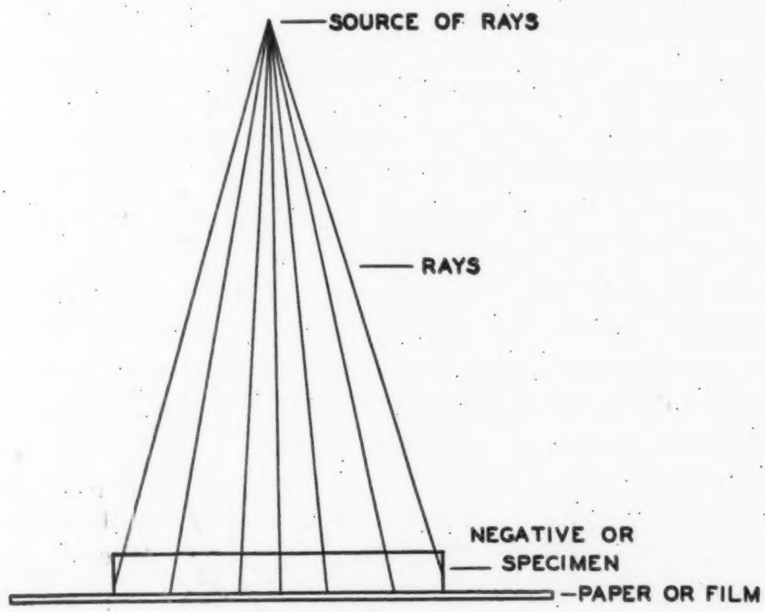


Fig. 1—Set-up for Contact Printing or Radiography.

routine examination of metal parts having thin sections in which the features to be detected are comparatively large. The work to be described in this paper, however, was carried out entirely by the photographic method of examination (i. e., radiography).

Radiography is fundamentally very similar to contact printing in ordinary photography. The set-up for both is shown diagrammatically in Fig. 1. The print and the radiograph are both shadowgraphs. In one case the light rays are absorbed by the silver grains in the emulsion of the negative, and in the other the X-rays are absorbed by the atoms of the specimen. As pointed out above, voids or gas inclusions in a metal specimen will absorb less energy from the X-ray beam than will the metal around them and corresponding dark spots will be obtained on the radiograph. On the other hand, a relatively dense iron or copper segregate in an aluminum alloy specimen will

absorb more energy from the X-ray beam than will the metal around it and a corresponding light area will be obtained on the radiograph.

In printing, however, conditions are ideal as compared to those of radiography. For example, the negative is thin and flat so that it can be held in close contact with the printing paper, insuring a clear print even with diffused light. On the other hand, radiographic specimens are of appreciable thickness and of various shapes so that many sections are often several inches from the film. This causes a loss of definition, the extent of which depends upon the relative size and location of the focal spot.

This is shown by the simple geometrical relations in Fig. 2. In Fig. 2a the focal spot is small and the cavity is near the film so that the definition obtained approaches that of a photographic print. In Fig. 2b where the cavity is farther from the film, the rays which are tangent to the hole cover a larger area so that the outline of the hole is less distinct than in Fig. 2a. With a large focal spot as shown in Fig. 2c, this condition becomes worse. If the distance from the focus to the film is decreased, a condition is finally reached as shown in Fig. 2d where some direct rays can strike all parts of the film without passing through the cavity. In this condition the dark spot obtained on the film has no well defined outline and appears as an indistinct darkened area much larger than the cavity. Figs. 2a and 2d also show the projection of the points A and B upon the film. It is evident that there is less distortion and greater definition with the arrangement shown in Fig. 2a. Consequently to get the best definition and the least distortion, a fine focus tube should be used and should be placed as far as practicable from the film. In most of the work with aluminum and magnesium which is described in this paper, 62 inches was the distance used. The distance from the defect to the film should be as small as possible. In radiographing ingots with a cross-section of 8 by 8 inches, it was found advisable to make two exposures with opposite sides of the ingot next to the film.

In Fig. 2 the only rays shown come from the focal spot on the target. In addition to these rays there are secondary rays[3] from objects in front of and behind the film, including the specimen itself. The secondary rays travel in all directions from many points and

[3]The energy of an X-ray beam passing through matter is dissipated in two ways. Some of it is scattered in all directions with but a slight change or no change at all in wave length. Some of the energy is used in ejecting electrons from the atoms. As other electrons take their place, X-rays are emitted which are of a longer wave length characteristic of the absorbing substance. Both the scattered and the characteristic radiation are included under the term "secondary radiation."

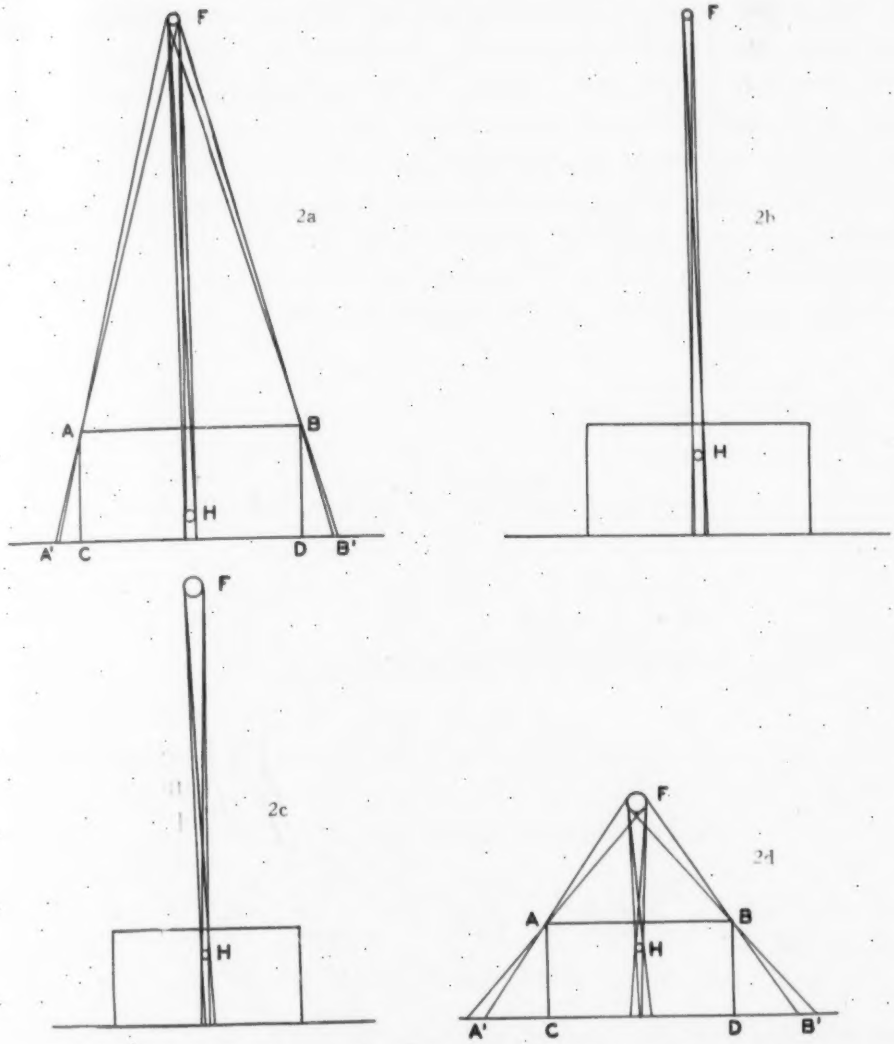


Fig. 2—Shows Effect of Relative Size and Location of Focal Spot on Definition. ABCD is Specimen. F is Focal Spot. H is Cavity in Specimen.

consequently cause a general fogging of the film. Moreover, the rays which do come from the focus but do not pass through the specimen may be so intense that fogging will occur at the edges of the specimen. This effect is similar to the fogging obtained on a film when an indoor picture is taken with the camera facing the window.

All of this undesirable radiation except that from the specimen can be blocked out to a large extent by the use of lead shot, lead sheet, lead powder, or by the use of a barium clay which has recently been put on the market for this purpose. Typical arrangements for this purpose are shown in Fig. 3.

It might seem that the presence of fogging would simply make the film darker and would not substantially decrease the contrast between two different parts of the film. However, as has been previously shown by Bragg and others, the use of a long exposure increases the contrast obtained. If there is much fogging the whole film may become opaque before a sufficiently long exposure has been obtained.

Even with a very careful blocking, such as is shown in Fig. 3, there is still a large amount of secondary radiation coming from the

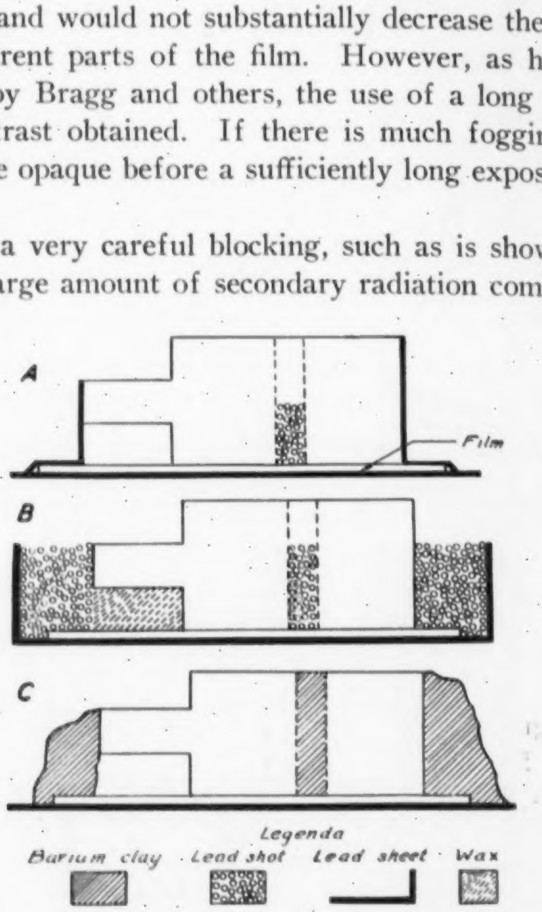


Fig. 3—Shows Typical Methods of Blocking.

specimen itself which appreciably decreases the contrast and definition obtained. The relative intensity of the secondary radiation can be decreased by the use of a filter screen or a Bucky diaphragm. A filter screen is metallic foil (lead, copper, or tin) placed in contact with the film on the side toward the specimen. That part of the secondary radiation of the specimen which consists of long wave length X-rays (characteristic radiation) is almost completely absorbed by such a filter screen. That part of the radiation which is about the same wave length as the primary X-rays (scattered radiation) is considerably reduced in intensity where it strikes the filter screen at an acute angle.

A Bucky diaphragm is shown diagrammatically in Fig. 4. The spaces between the lead sheet permit the passage of direct X-rays

and those secondary rays which are almost in line with the primary rays. The secondary rays which spread out at large angles to the primary rays are absorbed by the lead sheet. The sheets are kept in motion during exposure so that no record of them is obtained on the radiograph. The use of a filter screen is more convenient than that of a Bucky diaphragm and lead filter screens have been found very satisfactory for most of the work done by this company. For aluminum and magnesium specimens of moderate thickness, the set-up shown in Fig. 5 is satisfactory. For thicker specimens and for most steel specimens, blocking as shown in Fig. 3 is necessary.

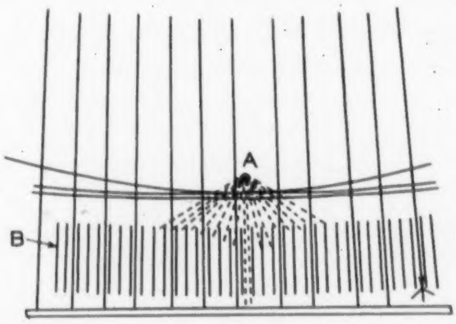


Fig. 4—Bucky Diaphragm. (Taken from Victor X-Ray Corp. Catalog.)
A—A source of secondary radiation.
B—Lead sheets.

These points which have just been mentioned have an important bearing on the size of defect that can be detected. This in turn determines the field of application of the method. For example, the defects in 8-inch square aluminum alloy ingots were found to be too small to be detected by raying the whole ingot, even under the best conditions. To get the desired information it was necessary to cut the ingot into slices and examine each slice.

Another important factor in obtaining sensitivity is the voltage across the tube. In general the contrast obtained increases as the voltage across the tube decreases,[4] and consequently it is advantageous to use as low a voltage across the tube as is practicable. This effect is

[4] As has been pointed out by Bragg and others, the ratio of the intensity of monochromatic rays passing through sound material to that of rays passing through a cavity is e^{-ud}.

u = absorption coefficient
d = thickness of cavity

(The effect of secondary radiation is not considered.) It will be noted that the thickness of the specimen does not enter into this expression. The smaller the value of e^{-ud}, the greater the contrast obtained on a radiograph. In other words, the greater u, the greater the contrast. In general, the lower the voltage across the tube (that is, the longer the wave length), the greater u becomes. This explains the experimental observation that greater contrast is obtained with lower voltages.

particularly noticeable in the case of magnesium. If the thickness of the specimen increases it is necessary to increase the voltage across the tube in order to secure a radiograph in a reasonable length of time.[5] Consequently the size of cavities which can be found by means of radiographs is indirectly a function of the thickness of the specimen.

Under conditions favorable to good contrast and definition, it was found possible to detect a cavity 1/16 inch thick in an aluminum ingot 8 inches thick provided that the cavity was in the half of the ingot next to the film. Smaller pores were not found on the radio-

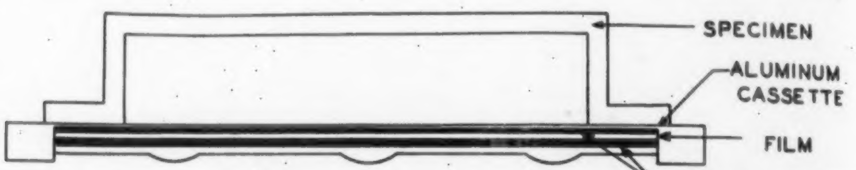


Fig. 5—Set-up for Thin Aluminum or Magnesium Specimens.

graph, although some were present in the ingot. In aluminum specimens 2 inches thick, cavities have been detected which were 1/64 inch thick. In sections of aluminum less than 1 inch thick, it is easy to detect cavities so small that they can not be seen on a machined surface.

The exposure time is one of the factors in determining the cost of radiographic inspection. Consequently it is advisable to decrease the exposure time provided a satisfactory radiograph can still be obtained. With high voltages the exposure time can be reduced and the quality of the radiograph improved at the same time by the use of lead screens. Lead foil is placed in contact with both sides of the film. The screen on the tube side of the film acts as a filter screen and both act as intensifying screens. That is, the lead absorbs energy which would otherwise pass through the film without affecting the emulsion and converts much of it into longer wave length X-rays or into the kinetic energy of photo-electrons. In these forms the energy is absorbed to a much greater extent by the film. There is on the market a cassette with lead screens on both sides of the film.

Other methods of decreasing the exposure time decrease somewhat the quality of the radiograph but they are sometimes advisable and in the case of thick specimens of heavy metals they are indispensable. Intensifying screens coated with calcium tungstate are more ef-

[5]If one were willing to use extremely long exposures the fogging due to secondary radiation would determine the length of exposure beyond which no advantage is obtained.

fective in shortening the exposure time than metal screens. Calcium tungstate has the property of transforming the energy of X-rays into that of visible and ultra-violet light. When these screens are used it is especially important to block out all of the radiation which does not go through the specimen. Fig. 6 shows a radiograph of a chromium-vanadium steel die block taken with the use of calcium tungstate screens. The boundary and some of the holes were blocked out with lead shot while some of the holes were not. Fogging is very evident around those holes which were not filled with lead shot.

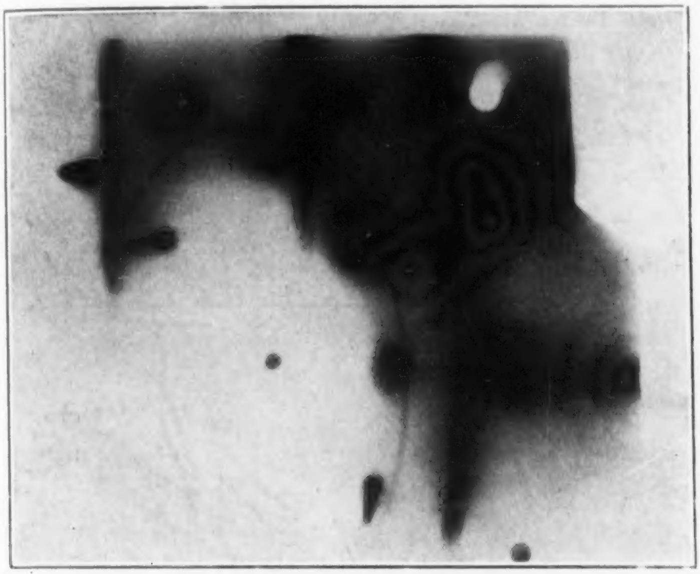


Fig. 6—Radiograph of Steel Die 2.25 to 2.50 Inches Thick.

As is indicated above, the exposure time can be reduced by increasing the voltage across the tube, but unduly high voltage decreases the contrast obtainable. The exposure time can also be reduced by placing the tube near the specimen since the intensity of the X-ray beam decreases inversely as the square of the distance from the focal spot. As shown above, too short a distance causes a distorted image and appreciable loss of definition.

The exposure conditions to be employed in any given case are determined by considering the above factors and making that compromise which seems most suitable. In general, the sensitivity will not be as great as in the preceding examples, but will be sufficient for the purpose and the exposures will be comparatively short. The exposure times necessary under different conditions are shown in Figs.

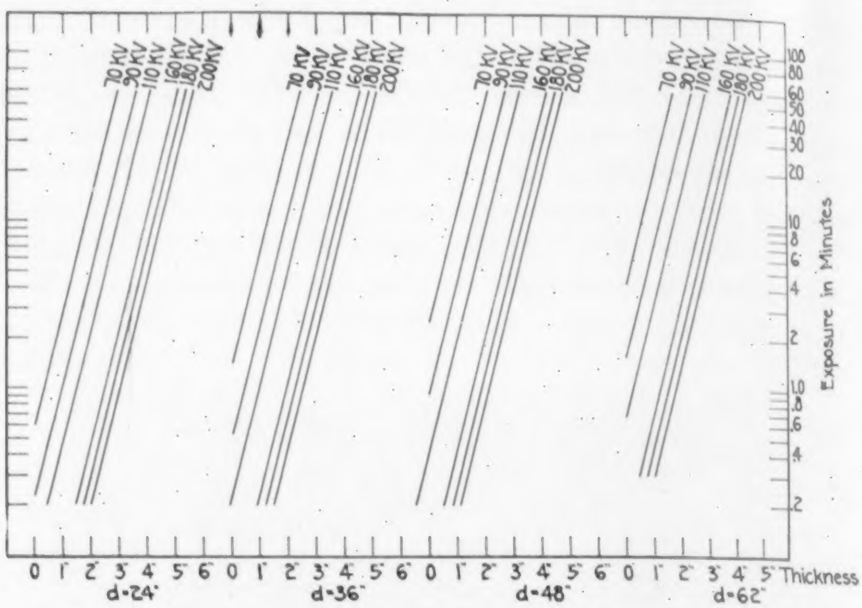


Fig. 7a—Exposure Curves for Aluminum with Lead Screens. d = Distance from Focus to Film. Current Through the Tube = 5.4 m.a.

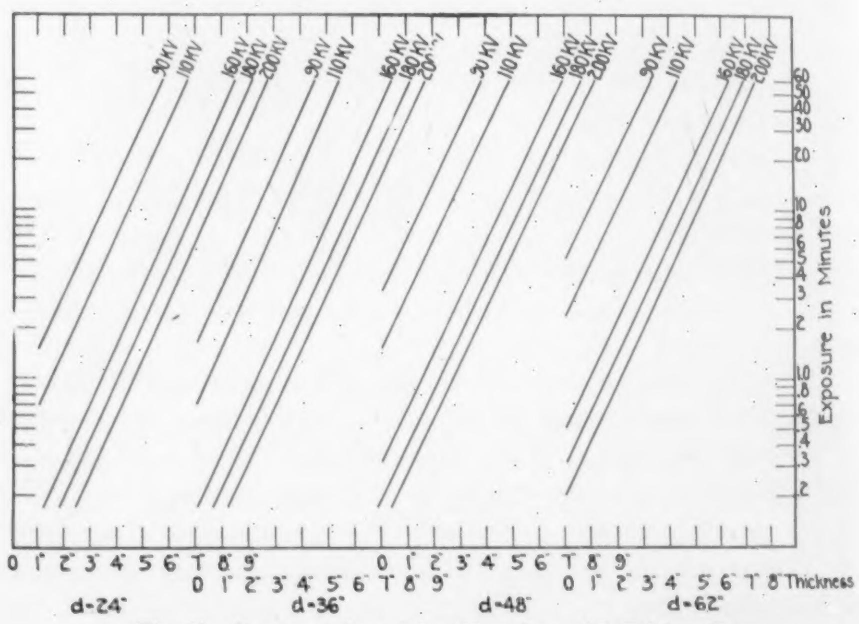


Fig. 7b—Exposure Curves for Alumnium with Calcium Tungstate Screens. d = distance from Focus to Film. Current Through the Tube = 5.4 m.a.

7a-7f. These curves were constructed from exposure records of good radiographs and some special exposures which were made for the purpose.[6]

[6]For other kinds of apparatus and screens these curves would have to be modified.

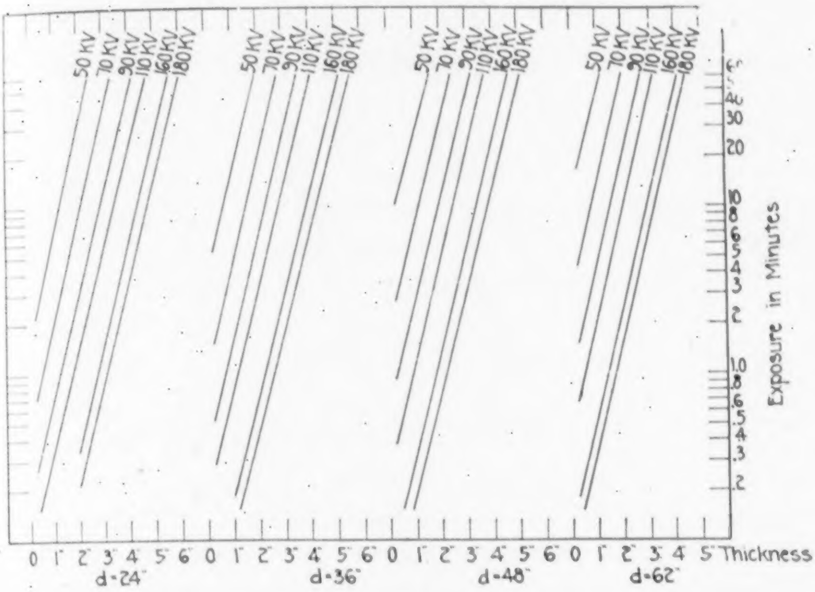


Fig. 7c—Exposure Curves for Magnesium with Lead Screens. d = Distance from Focus to Film. Current Through the Tube = 5.4 m.a.

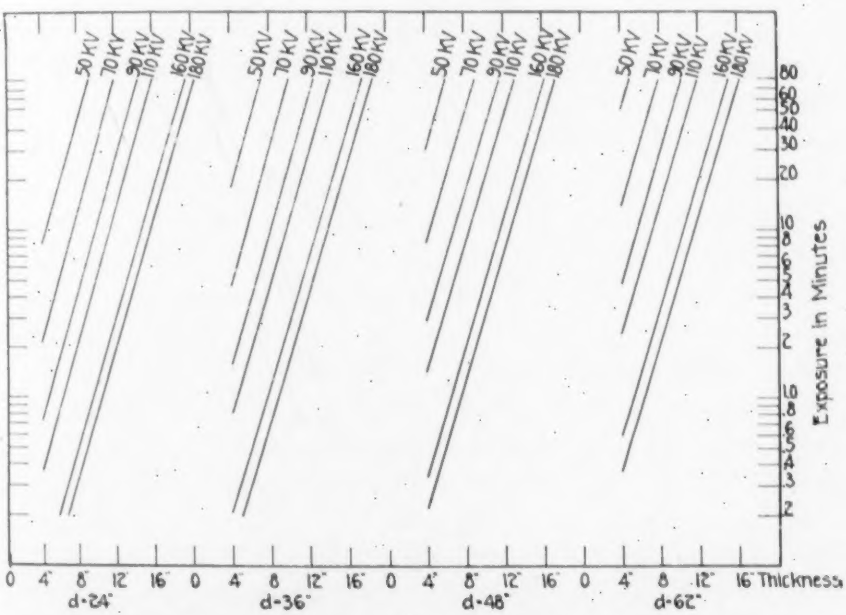


Fig. 7d—Exposure Curves for Magnesium with Calcium Tungstate Screens. d = Distance from Focus to Film. Current Through the Tube = 5.4 m.a.

After a little practice in selecting the proper exposure conditions, these exposure curves make it easy to obtain good radiographs of castings having substantially uniform thickness. However, most

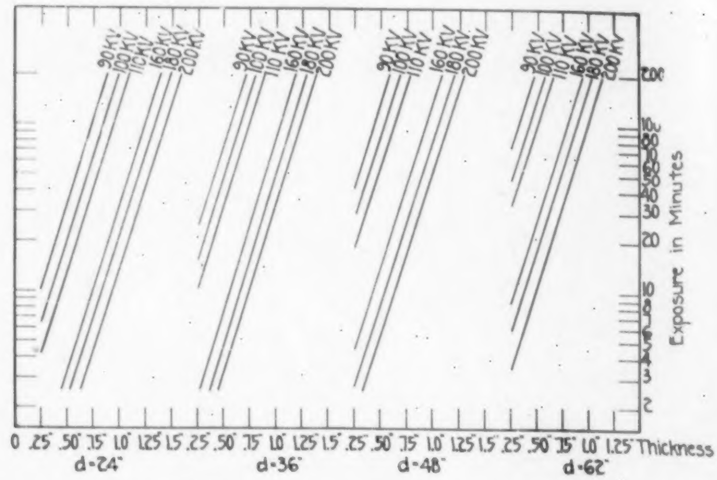


Fig. 7e—Exposure Curves for Iron with Lead Screens. d = Distance from Focus to Film. Current Through Tube = 5.4 m.a.

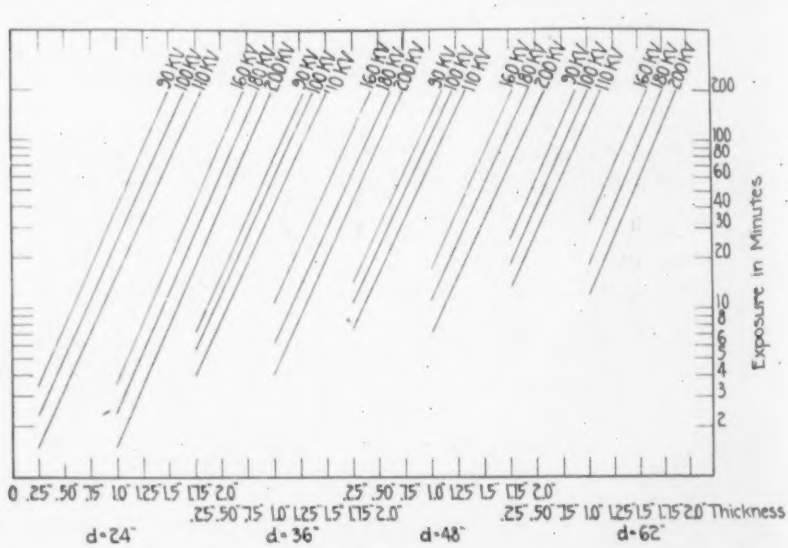


Fig. 7f—Exposure Curves for Iron with Calcium Tungstate Screens. d = Distance from Focus to Film. Current Through Tube = 5.4 m.a.

commercial castings vary in thickness from one part of the casting to another and the optimum exposure time as determined from the above curves differs greatly for different parts of a casting. Actually, there is a rather large permissible latitude in exposure time and if the differences in thickness are not too great, one exposure will give satisfactory results for the whole casting. In a large percentage of the work encountered, however, this is not the case and some special procedure is required.

In the case of aluminum, the range of thickness which can be satisfactorily handled by one exposure is increased by filtering out the long wave length X-rays by means of an aluminum filter placed near the tube. A large sheet of lead foil placed over the casting will answer the same purpose, and is also applicable to brass or steel. This method involves a decrease in contrast, especially in the thin sections, and its application is therefore limited.

Obviously, two radiographs can be made, one for the thick sections, the other for the thin sections, but the examination of two radiographs is not as convenient as that of the one radiograph showing all the sections. Such a method is also expensive on account of the large amount of film required.

A very good method of obtaining a good exposure for all sections on one film is to block out the thin sections with sheet lead and expose the heavy sections. Then remove the lead and expose the thin sections, using a lower voltage. If the casting is complicated so that a large number of thin sections of complicated shape are encountered, this method is not suitable.

Another method which enables a satisfactory radiograph to be made with one exposure is to apply to thin sections such thickness of lead foil that a good exposure is obtained throughout. This method involves appreciable loss of sensitivity for the thin sections, and therefore is not suitable for detecting minute pores or dross films in thin sections, but it is useful for making a general survey of a specimen.

Another method which was proposed by Dr. Ancel St. John is to immerse the specimen in a liquid or fine powder having an absorption coefficient somewhat less than that of the specimen. Carbon tetrachloride has been used successfully for aluminum in this laboratory. A solution containing 35 grams of barium chloride in 100 cubic centimeters of water was recommended by H. Pilon and A. Laborde for aluminum. The same authors recommended a solution containing 150 grams of barium iodide in 100 cubic centimeters of water for iron or copper. The Eastman Kodak Company recommends a solution containing 3.5 pounds of lead acetate and 3.5 pounds of lead nitrate in a gallon of water for iron and steel specimens. Dr. St. John recommends ethylene iodide for steel. This method has the same disadvantages as the preceding methods but has certain advantages. The immersion method renders blocking unnecessary, and eliminates from the radiograph all traces of small surface pits or other roughness.

Frequently castings have on the surface pits or other defects which will be machined off, or which are so small or located in such a manner that their presence is permissible. If the radiograph of such a casting is made in the ordinary manner these surface imperfections will all be recorded on the radiograph. This makes it necessary to carefully compare the casting and the radiograph in order to decide which of the defects are internal. It is often advantageous to eliminate surface defects from the radiograph either by the immersion method mentioned above or by coating the rough area of the specimen with a thin film of paste having approximately the same absorption coefficient as the specimen. For iron, "Smooth-On" cement is satisfactory. For aluminum, a suitable paste can be made by mixing 200-mesh $CuAl_2$ and petroleum jelly. For magnesium, zinc oxide ointment is satisfactory.

Obviously, one exposure is incapable of showing the location of a defect in the direction normal to the plane of the radiograph. Therefore, in cylindrical shaped pieces or pieces with 2 or 3 thin walls parallel to each other, it is impossible to tell in which wall the defect is located. Such defects, however, can be completely located by taking two exposures of the same section at different angles. Since we are accustomed to reading drawings with projections at 90 degrees to each other, it is rather easy to locate defects from two radiographs taken at 90 degrees to each other, provided the defects are so few and so different that there is no doubt as to the identity of the defects in the two views. In some cases, due to the shape of the casting, a smaller angle is convenient, but the localization is then more difficult. Where the defects are sufficiently large to be easily shown, two exposures can be made on one film, leaving the position of the film and the specimen unaltered but shifting the tube a measured distance between the exposures. Simple geometrical considerations give the location of the defect from the distance between its two images.

An excellent method which permits one to visualize the condition of the specimen better than the others consists of making stereoscopic views, that is, two radiographs with the tube shifted between exposures by an amount which corresponds to the interpupillary distance. These radiographs are then viewed through a stereoscope. In examining stereoscopic pairs, distortion is automatically corrected and one gets the impression of looking through a three-dimensional specimen.

In the localization of defects, it is essential to have reference

points. In the case of small articles the outline of the specimen can usually be used for this purpose. For larger articles where a number of films are required to make a complete survey, other reference points must be used. In the case of aluminum castings, it is convenient to paint numbers on the castings with a lead paint. This leaves a permanent record on the casting and the number is shown on the radiograph without blocking out defects which occur under the figure. Another method which can also be applied to iron is to glue a small piece of lead foil on the surface of the casting and cut a number in it with a steel stencil. This leaves a stencilled number on the surface of the casting after the lead foil is removed.

The development of the X-ray films is a simple process. The film is fitted into a developing hanger and left in the hanger during the developing, fixing, washing, and drying. The tank method of development is the most satisfactory. The temperature of the developer and hypo can be maintained at the desired point by controlling the temperature of the water flowing through the washing compartment. This makes possible a standard length of development. This system of development will give uniform results if the film has been given the proper exposure. Metol-hydrochinone developer having a low alkali content has been found to give good results for a month or more when kept in an open tank. The fixing and washing are carried out in other compartments of the same tank. The films are finally dried in a rack which permits free circulation of air.

In order to get the greatest possible amount of information from a radiograph, it is necessary to carry out the examination under carefully controlled conditions. The room should be darkened so that the only bright light reaching the eyes comes from the viewing box through the film. The viewing box should be so designed that a uniform diffuse illumination is obtained over the whole film. A rheostat should be placed in the lighting circuit so that the intensity of the illumination can be varied to suit the density of the radiograph being examined. In examining dense areas, it is frequently advantageous to cover the transparent portions of the film with black paper.

In presenting the results of radiographic examinations, it is necessary to have some means of reproducing radiographs. It is much more difficult to obtain good contact prints than in the case of ordinary photographs, due to the wide range of densities found on the same film. Good contact prints from contrasty negatives have been ob-

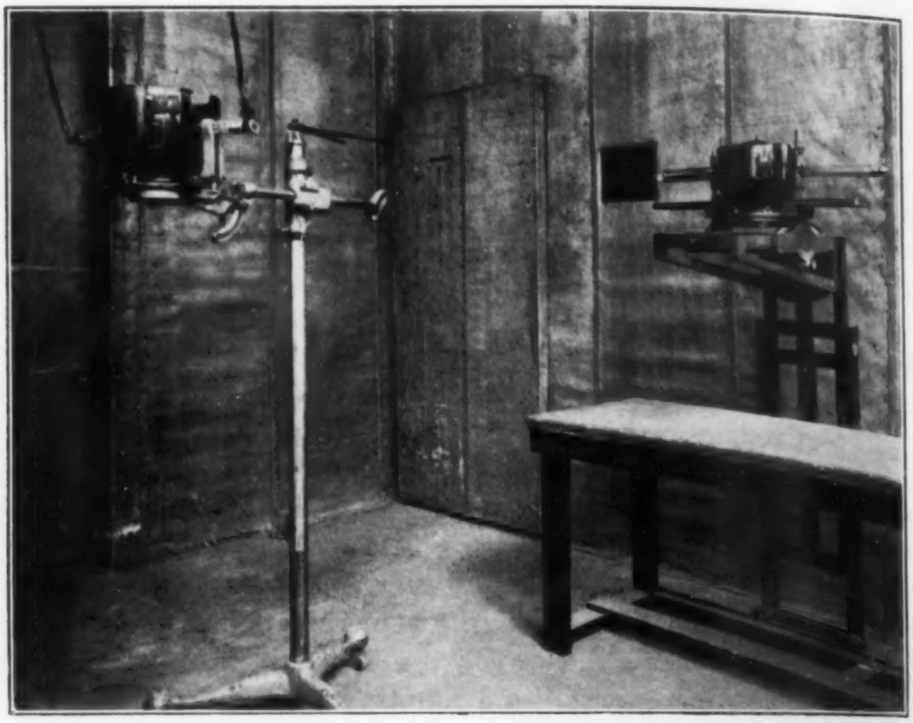


Fig. 8a—X-ray Room.

tained in this laboratory by the use of P. M. C. bromide paper #1, or "Azo" paper, #0. Amidol or metol developers have been found to give somewhat more satisfactory results than the metol-hydrochinone, though metol-hydrochinone developer of proper dilution will give satisfactory results if the proper grade of paper is selected.

The best quality of reproduction has been obtained by a more round-about method.[7] The films are placed in the viewing box and photographed using a portrait film. It is then a simple matter to obtain a good print from this film. This method has the added advantage of giving a reproduction like the film, whereas in the contact print there is a complete reversal; that is, a dark spot on a film appears as a light spot on a contact print. It will be noted that Figs. 6, 14, 16, 18, are made from such reproductions.

X-Ray Installation

A combination diagnostic and deep therapy outfit which was originally developed for medical work was installed without altera-

[7]This method has been used for some time by Dr. David Steel of the City Hospital at Cleveland.

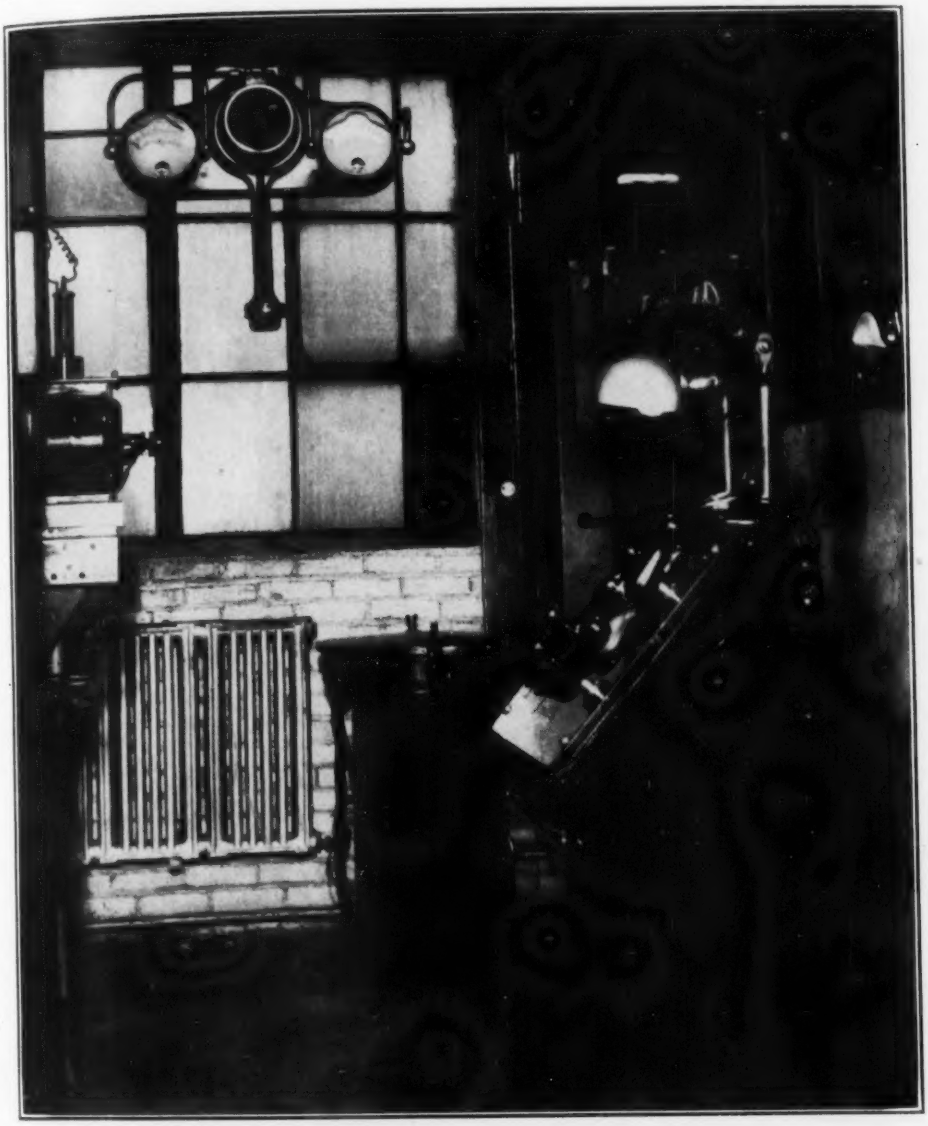


Fig. 8b—Control Room and Part of Transformer Room.

tion. There are certain details of installation which are probably of sufficient interest to be mentioned. The interior walls of the X-ray room are lined with 1/8-inch sheet lead and tests with dental films have shown that this is a sufficient thickness of lead for voltages up to 200,000 volts, which is the rated maximum voltage for the outfit. Dental films have also been used to test the amount of radiation which gets through a brick wall 13 inches thick. No fogging was produced by an exposure of two weeks.

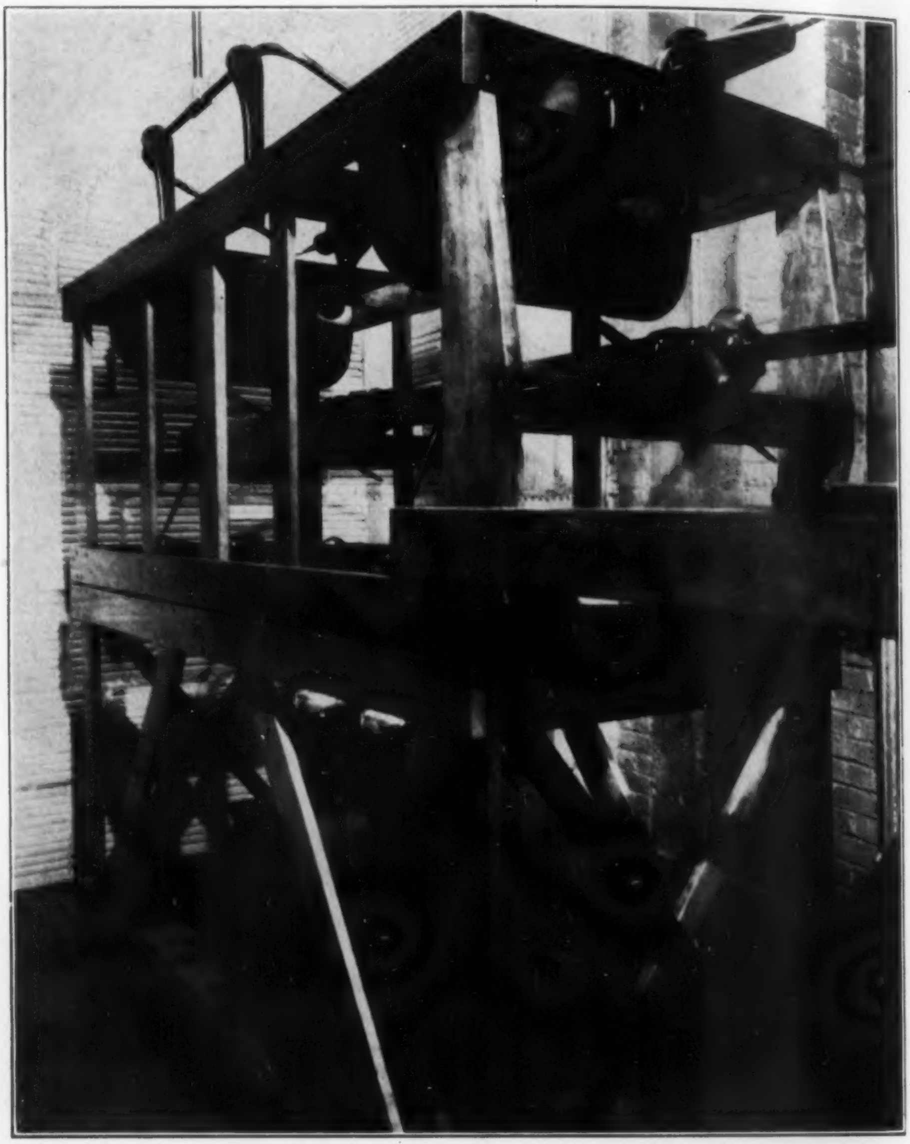


Fig. 8c—Transformer and Rectifier.

The operator stands in a separate control room and views the tube through a window of two thicknesses of lead glass. A step-up transformer and rectifier are in a separate room to one side of the control room. In the control room is a master switch of the no-load circuit-breaker type. The solenoid of this switch is connected in series with switches in all of the doors to the X-ray and transformer rooms. Consequently, if anyone walks into either the X-ray room

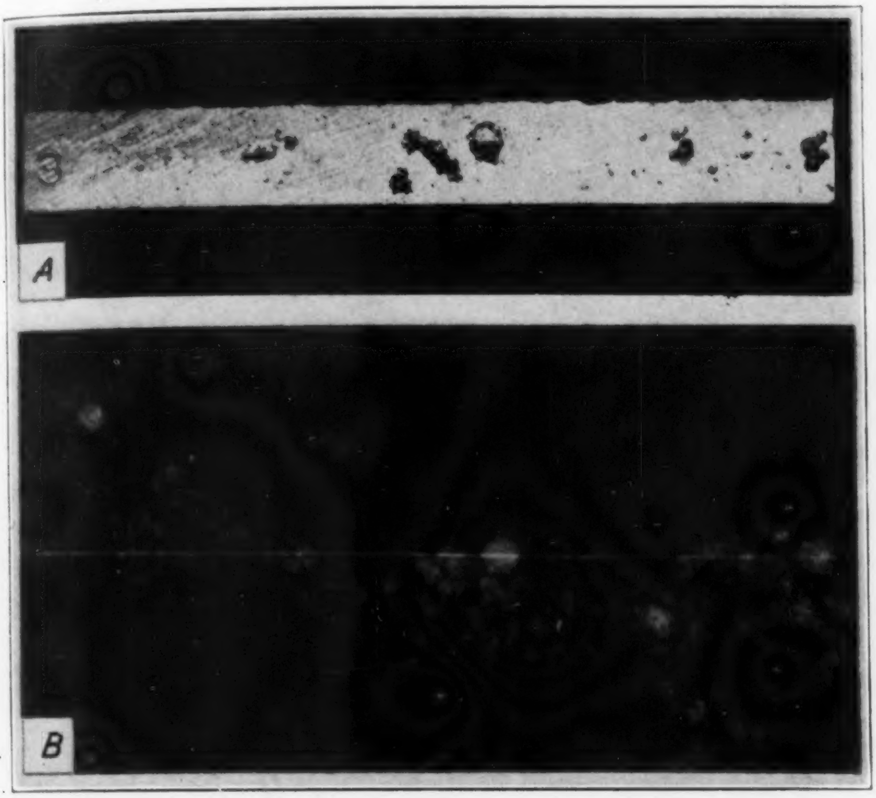


Fig. 9—Blowholes and Pinhole Porosity in Aluminum Alloy Sand Casting. 9A is Section of Casting Cut Along White Line of 9B. 9B is Radiograph.

or transformer room, the outfit is automatically shut off. Figs. 8a-8c show the different parts of the installation.

Some Industrial Applications of Radiography

Most of the macroscopic defects in metals can be revealed by X-rays. Those which are most readily detected are shrinks, blowholes, pinhole porosity, and segregates. Dross and other inclusions are usually detected but may in certain cases escape detection, when the absorption coefficient is nearly the same as that of the metal. Fine cracks and laminations in forgings can be revealed easily, provided the X-rays pass through the piece nearly parallel to the crack or lamination. However, if the X-rays pass through the piece normal to the plane of the lamination or crack, there is no indication on the radiograph that such a defect exists. This is brought out in Fig. 6. There ap-

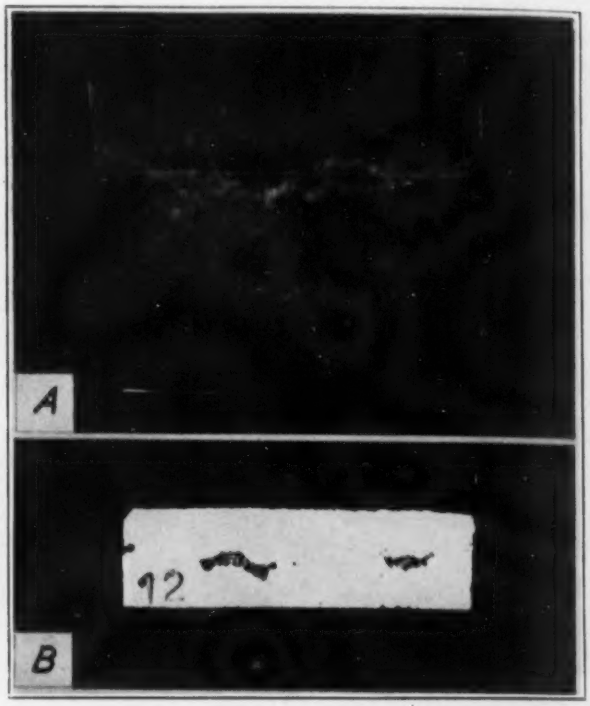


Fig. 10—A Shrink and Pinhole Porosity in Aluminum Alloy Sand Casting.

pear to be two cracks in the die block shown. As a matter of fact, there is one S-shaped crack and the direction of the crack is approximately the same as that of the X-rays near each surface of the die block. Near the center of the block the crack makes a large angle with the X-ray beam and leaves no record on the film.

The appearance of some typical defects is shown in Figs. 9 to 12. Fig. 9B is a part of the radiograph of an aluminum alloy sand casting showing blowholes and pinhole porosity. The larger white spots indicate blowholes and the fine white specks which are finely distributed over the radiograph indicate pinhole porosity. The horizontal white line is a pencil mark on the film showing where the casting was sectioned. Fig. 9A is an ordinary photograph of the section of the casting indicated on the radiograph. Figs. 9A and 9B are in vertical alignment.

Figs. 10A and 10B are a similar pair showing the appearance of a shrink on a radiograph and on the surface of a cross-section. Pinhole porosity is also present.

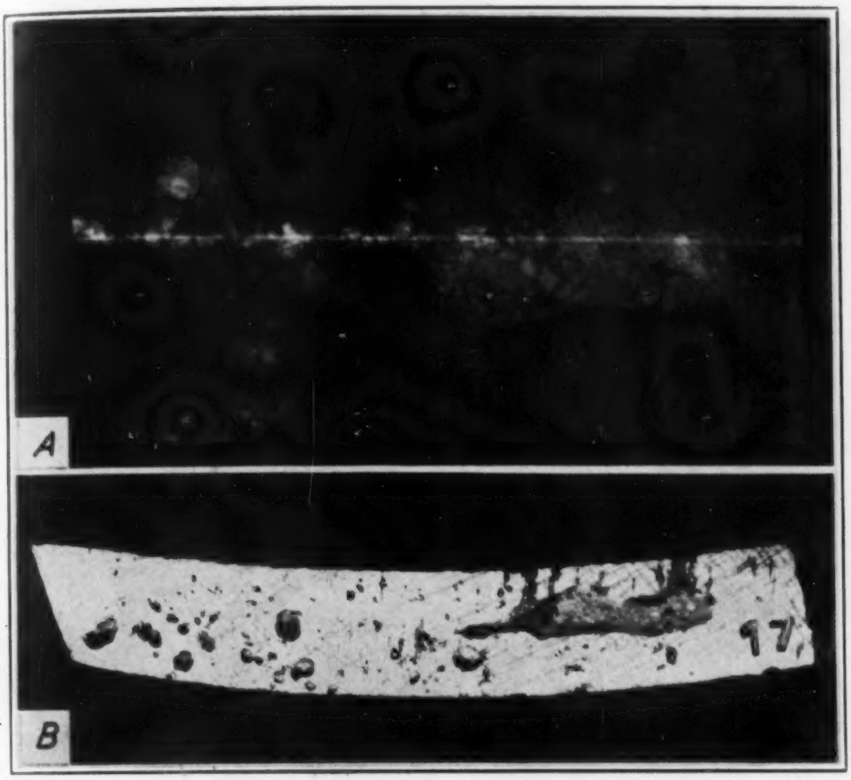


Fig. 11—Inclusion, Blowholes, and Pinhole Porosity in Aluminum Alloy Sand Casting.

Figs. 11A and 11B in a like manner show an inclusion of refractory material (the elongated area at the right), blowholes, and pinhole porosity. The ability to properly interpret a radiograph is acquired by sectioning many specimens in the manner illustrated in these figures.

Fig. 12 shows several different kinds of defects. The arrows and notes give the interpretations. Other examples of the appearance of defects will be given under the various applications to be considered below.

Radiography has proved a most useful tool in the development of welding methods for aluminum castings. Fig. 13A shows a set of welded cast test bars which represent the state of the art at the time the X-ray apparatus was installed. Fig. 13B shows the kind of welds which it is now possible to make. Welds of this kind are good enough to be used in some cases in repairing highly stressed castings. Tensile tests, examination of fractures, and microscopic examination were used to supplement the X-ray examination of these bars.

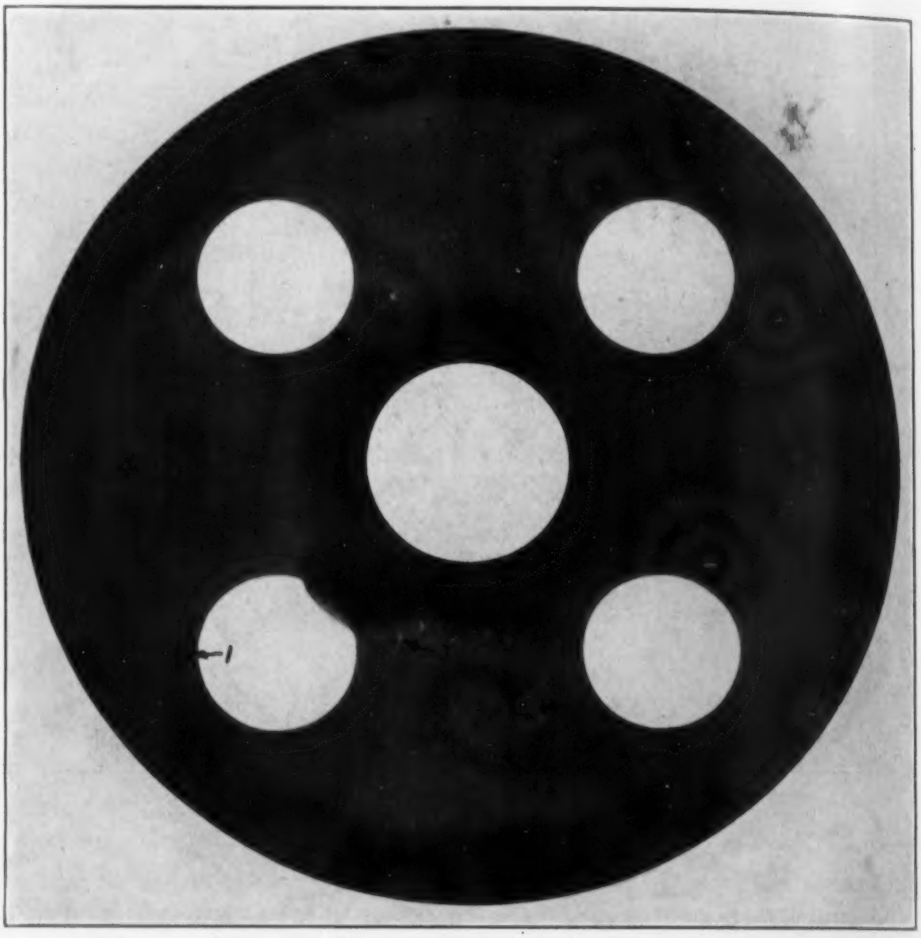


Fig. 12—Aluminum Alloy Sand-Cast Wheel. 1, Inclusion. 2, Dross. 3, Shrink. 4, Pinhole Porosity.

Radiography is a rather expensive method of inspection and consequently it is seldom used for 100 per cent inspection. There are, however, a few special cases in which X-rays have been used to advantage for routine inspection. For example, a manufacturer of Diesel engines was interested in using aluminum connecting rods but felt that the production on the particular engine in question was not sufficiently great to justify the expense of a forging die. On the other hand, these rods were subjected to severe service conditions and it was felt that the possibility of casting defects in some of the rods would ordinarily eliminate aluminum alloy sand castings from consideration. It was found that sand-cast, heat treated aluminum alloy connecting rods which were selected on the basis of 100 per cent X-ray inspection were entirely satisfactory.

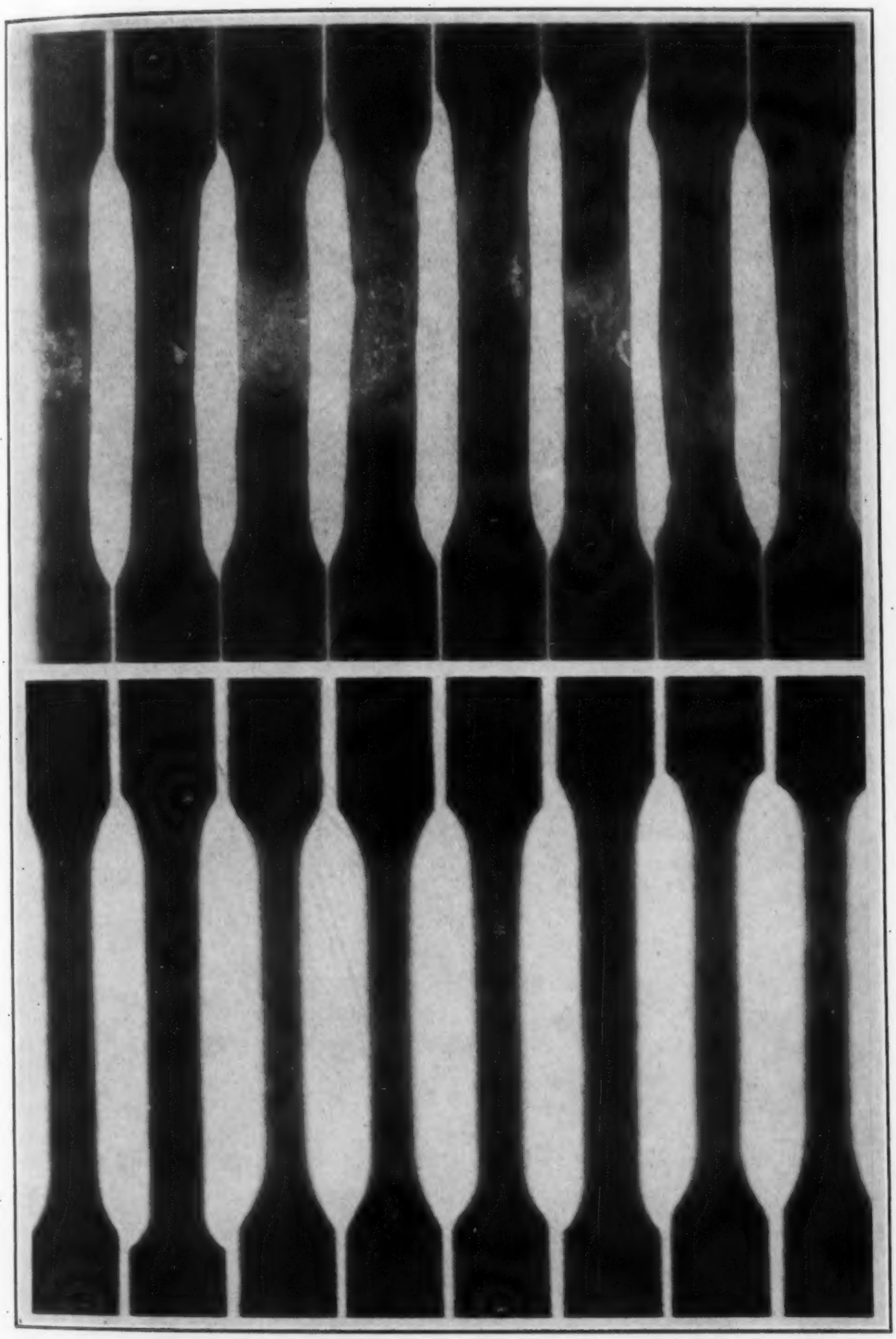


Fig. 13A (Upper)—Welded Sand-Cast Test Bars—Method of Welding Practiced When X-ray Work was Begun.
Fig. 13B (Lower)—Welded Sand-Cast Test Bars—Latest Method of Welding.

It has also been found that the inspection of an occasional casting taken at random from the general production will occasionally find defects due to inadvertent changes in foundry practice which were made after a satisfactory technique had been worked out. This is particularly true if the casting has been out of production for some time.

In developing heat treatments and methods of forging or rolling, it is desirable to have for experimental work samples of a uniformly

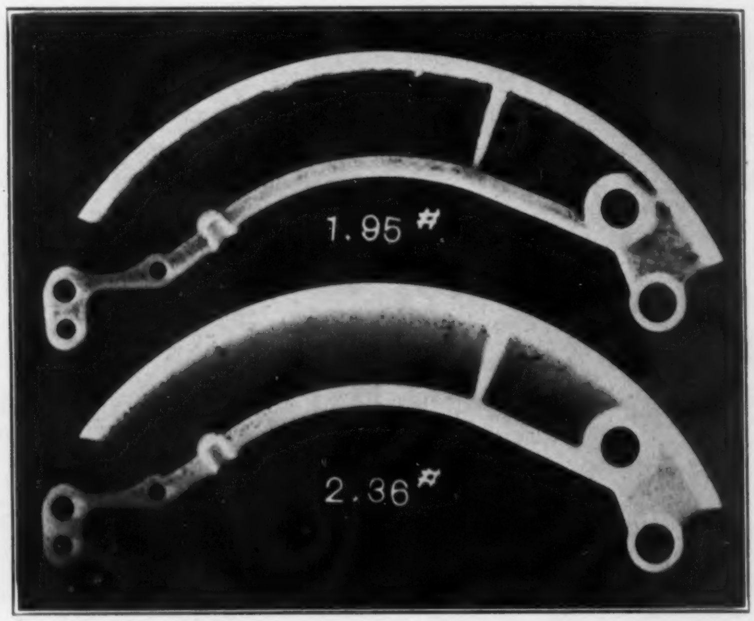


Fig. 14—Die-Cast Brake Shoes.

high quality. In this case more than the required number of samples are made and all of them are X-rayed and even those which have slight defects are discarded. This eliminates at the beginning certain factors which might otherwise vitiate the results of the experiment.

As a result of Dr. H. H. Lester's well known work at Watertown Arsenal, he concluded that the most important use of radiography is in the development of satisfactory fabricating methods. The experience in this laboratory has confirmed his conclusion. A few examples of such use are given below.

Radiography has been helpful in getting die casting dies into satisfactory operation with a minimum delay. An example of this use of radiography is illustrated in Fig. 14. The upper shoe is one of the

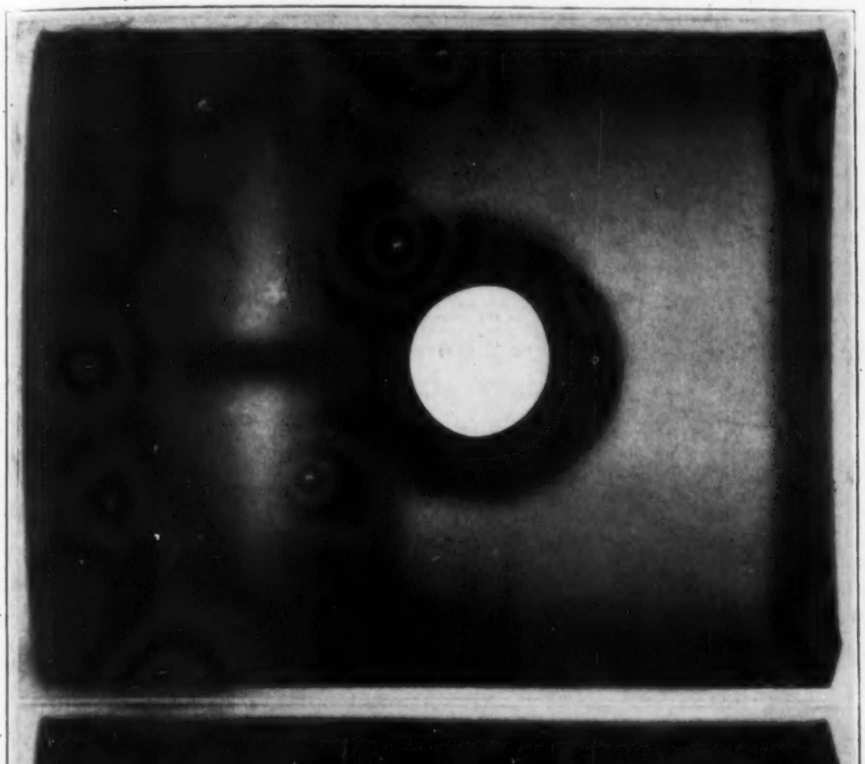


Fig. 15A (Upper)—Permanent Mold Pistons—First Method of Operating Mold.
Fig. 15B (Lower)—Permanent Mold Pistons Improved Method of Operating Mold.

first castings produced in a new die. Several variations in operating conditions were tried, the results being followed by radiographic examination of the castings produced, and the method of operating which gave the best castings was adopted for production. The lower shoe is one of the better castings produced in the same die. The weights of the castings were correlated with the porosity as shown in the radiographs. After the parts were put into production, X-ray examination was eliminated but each casting was weighed.

Figs. 15A and 15B show aluminum alloy pistons which were cast in a permanent mold. The piston shown in Fig. 15A was made soon after the mold was put into operation. The piston shown in Fig. 15B was made after some experimental work to determine a satisfactory method of operating the mold.

In the case of dies or permanent molds, it is slow and expensive to make changes in the method of gating. In the case of sand castings, however, several methods of gating and chilling the castings can be tried in a short time at a relatively low cost. Consequently the most rapid progress has been made in the case of sand castings. Fig. 16A shows the first airplane shock absorber casting made from a new pattern. After four changes in the method of gating, checking the results of each change radiographically, a method was found which produced castings as shown in Fig. 16B.

The size of chills used and the position of the chills with respect to the gates and risers are important factors in determining the amount of pinhole porosity. Fig. 17A shows a part of the first sand casting produced from the new pattern. It will be noted that there is considerable pinhole porosity throughout this section of the piece. After suitable change in the method of chilling, castings were obtained as shown in Fig. 17B.

In the case of heavily stressed parts, break-down tests are made on sample castings with the loading as nearly as possible like that which the castings are to receive in service. This locates the points of maximum stress and particular attention is paid to these areas. Gates, risers and chills are so located and proportioned that the soundest and strongest metal will occur at the point of maximum stress. In some cases the breaking load for the castings which are shipped to the customer is 50 per cent greater than that of the first casting produced.

It is a rather common practice in foundries in pouring metal into

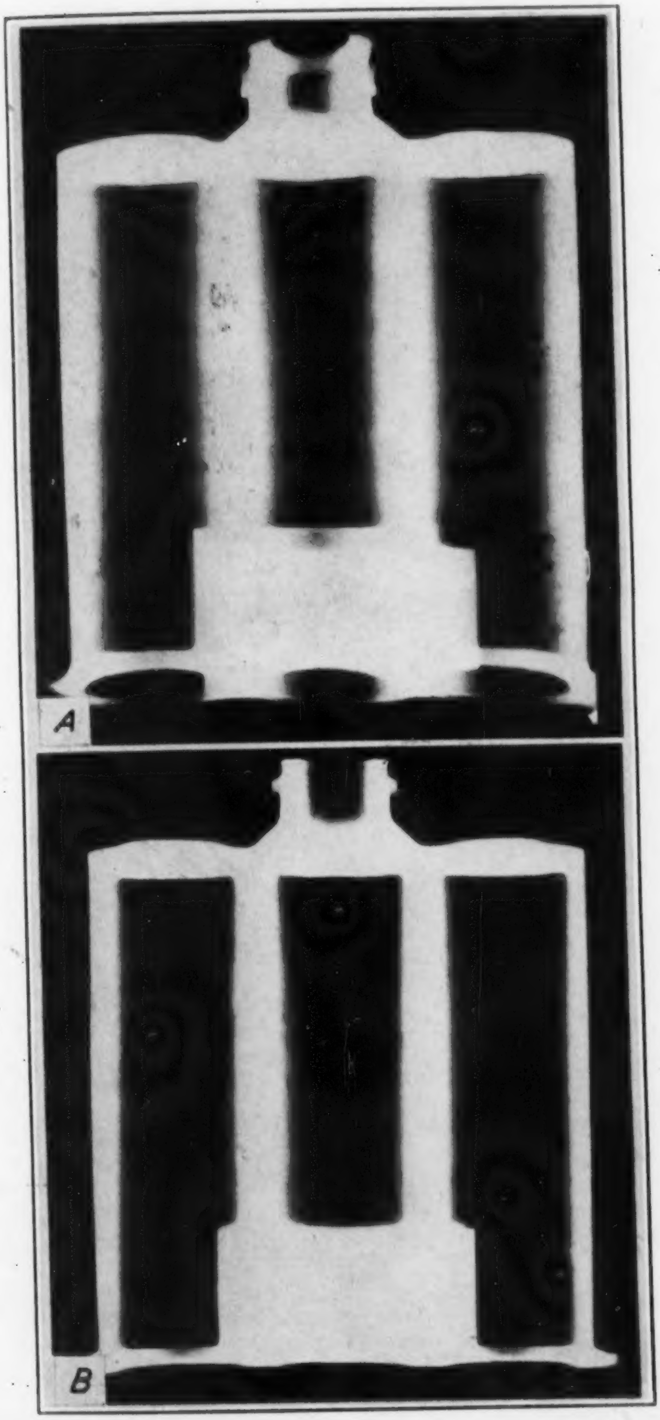


Fig. 16A—Air-plane Shock Absorber, First Method of Casting.
Fig. 16B—Airplane Shock Absorber, Final Method of Casting.

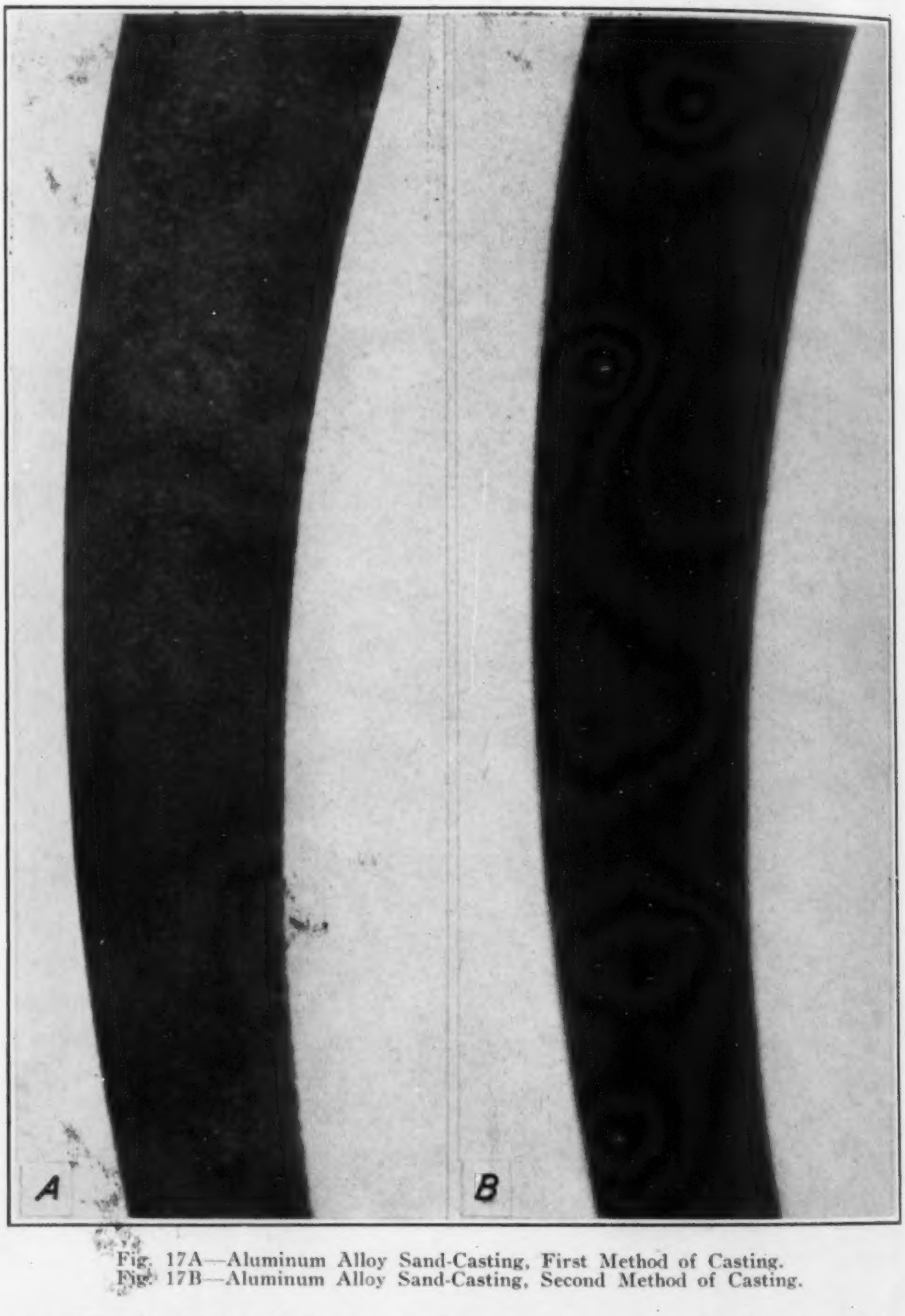


Fig. 17A—Aluminum Alloy Sand-Casting, First Method of Casting.
Fig. 17B—Aluminum Alloy Sand-Casting, Second Method of Casting.

a mold to hold the ladle some distance above the mold to impart a high velocity to the metal and thus cause it to fill the mold. In the case of aluminum alloys, this practice is objectionable on account of the increased amount of dross and oxide which is formed and stirred

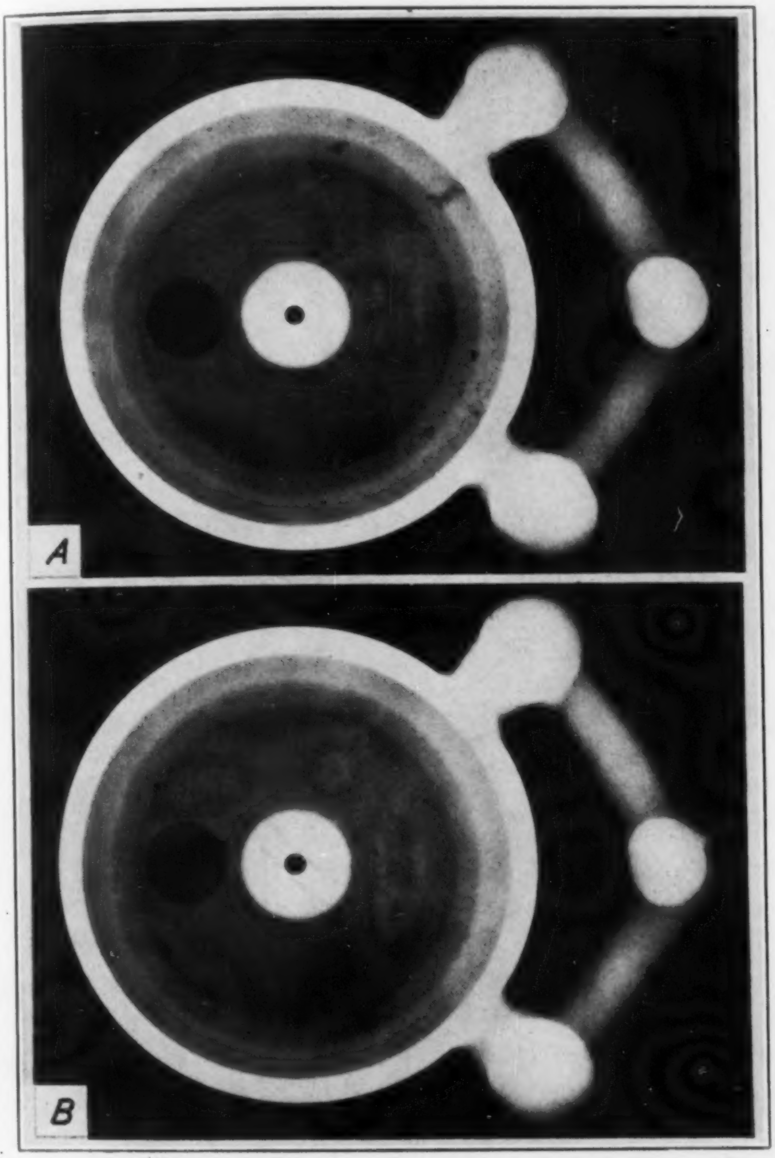


Fig. 18A—Aluminum Alloy Sand Casting Poured with Ladle 12 Inches Above Mold.
Fig. 18B—Aluminum Alloy Sand Casting Poured with Ladle as Close to Mold as Possible.

into the metal. It is also probable that air is more easily stirred into aluminum and retained in the casting than in the case of other metals of higher specific gravity. By means of radiographs it has been shown that in many cases at least sounder aluminum castings are produced by holding the ladle as near the mold as possible. Figs. 18A and 18B illustrate this point. Fig. 18A represents a casting which was poured

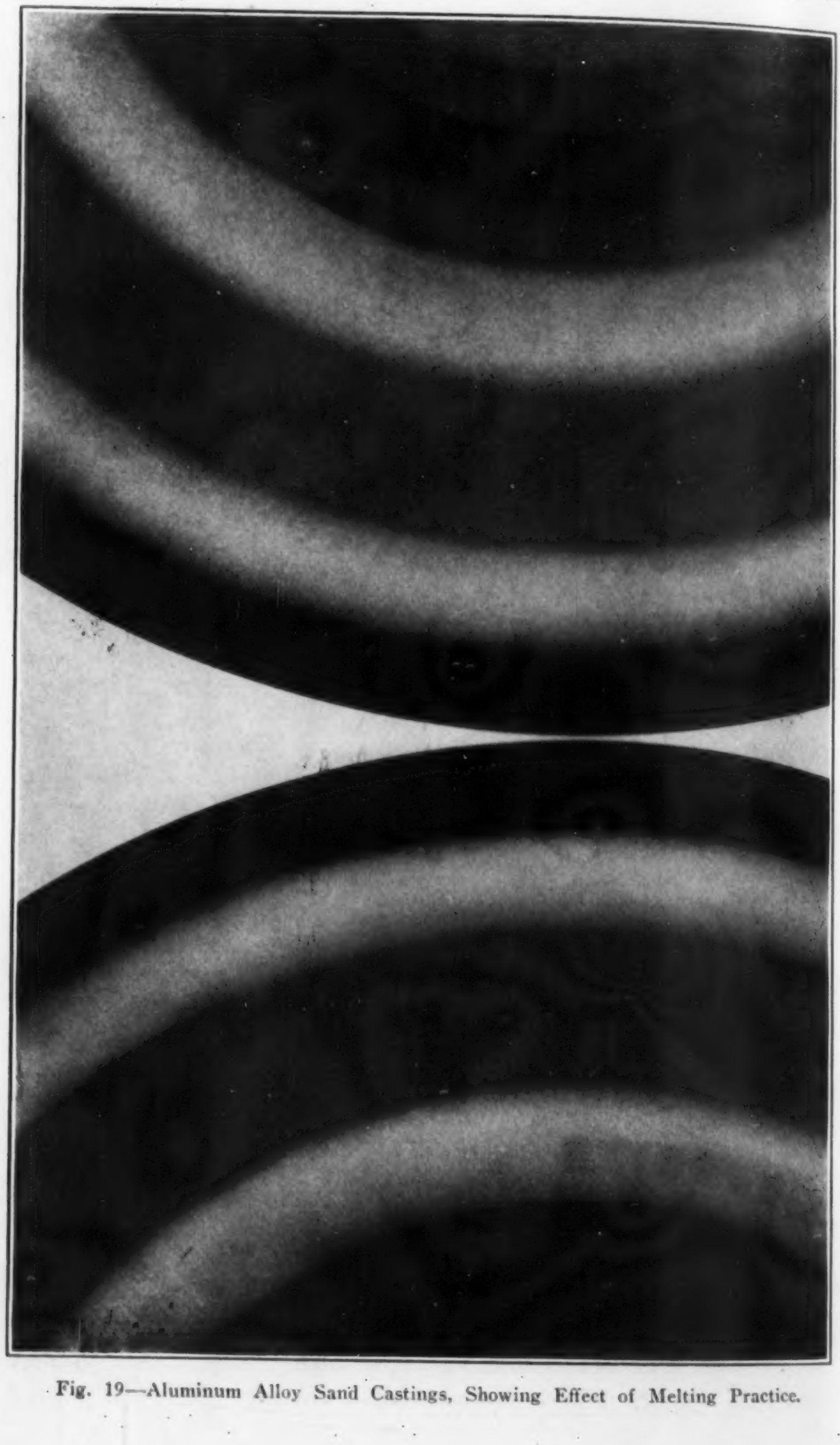


Fig. 19—Aluminum Alloy Sand Castings, Showing Effect of Melting Practice.

with the ladle twelve inches above the mold. Fig. 18B represents a casting which was poured with the ladle as close to the mold as possible. This point is covered more fully elsewhere.[8]

The effects of melting practice, condition of the sand, kinds of cores and pouring temperatures upon the soundness of castings are readily followed by radiography. Fig. 19 will serve as an example. The only difference in the methods of making the two castings shown was in the melting practice.

X-ray examination has been used to a limited extent in improving

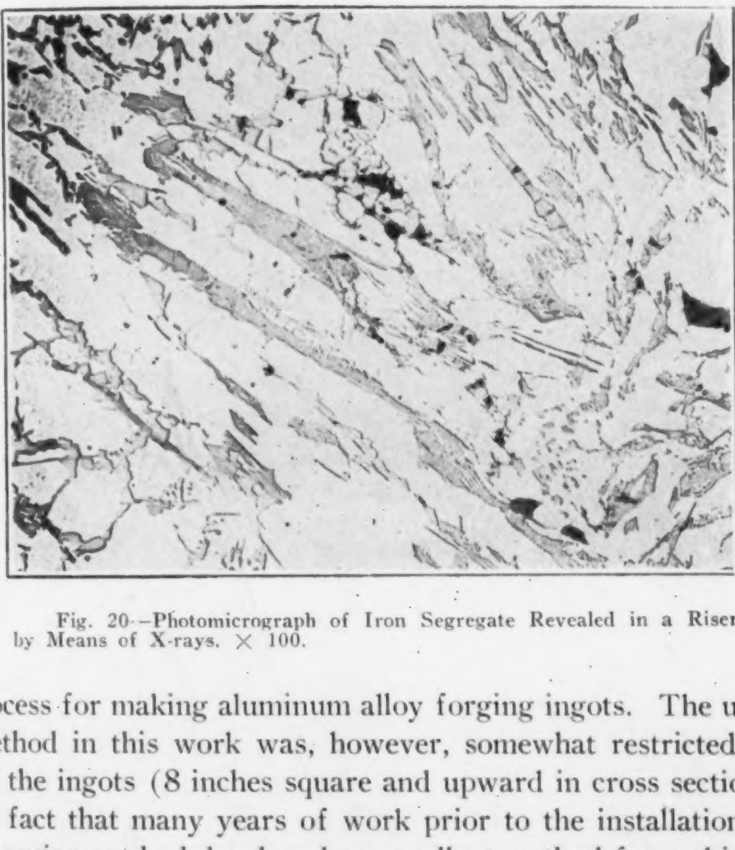


Fig. 20—Photomicrograph of Iron Segregate Revealed in a Riser by Means of X-rays. × 100.

the process for making aluminum alloy forging ingots. The utility of the method in this work was, however, somewhat restricted by the size of the ingots (8 inches square and upward in cross section) and by the fact that many years of work prior to the installation of the X-ray equipment had developed an excellent method for making these ingots. In normal ingots the defects were too small to be detected in an 8-inch thickness. These small defects were revealed easily in radiographs of slices 1-inch thick cut from the ingot, but the sawing of the ingot is expensive and of course destroys the ingot. Considerable information about the ingots has been obtained by X-raying

[8] "The Importance of Standard Pouring Heights for Aluminum Castings," by D. B. Hobbs, *Foundry*, September, 1929.

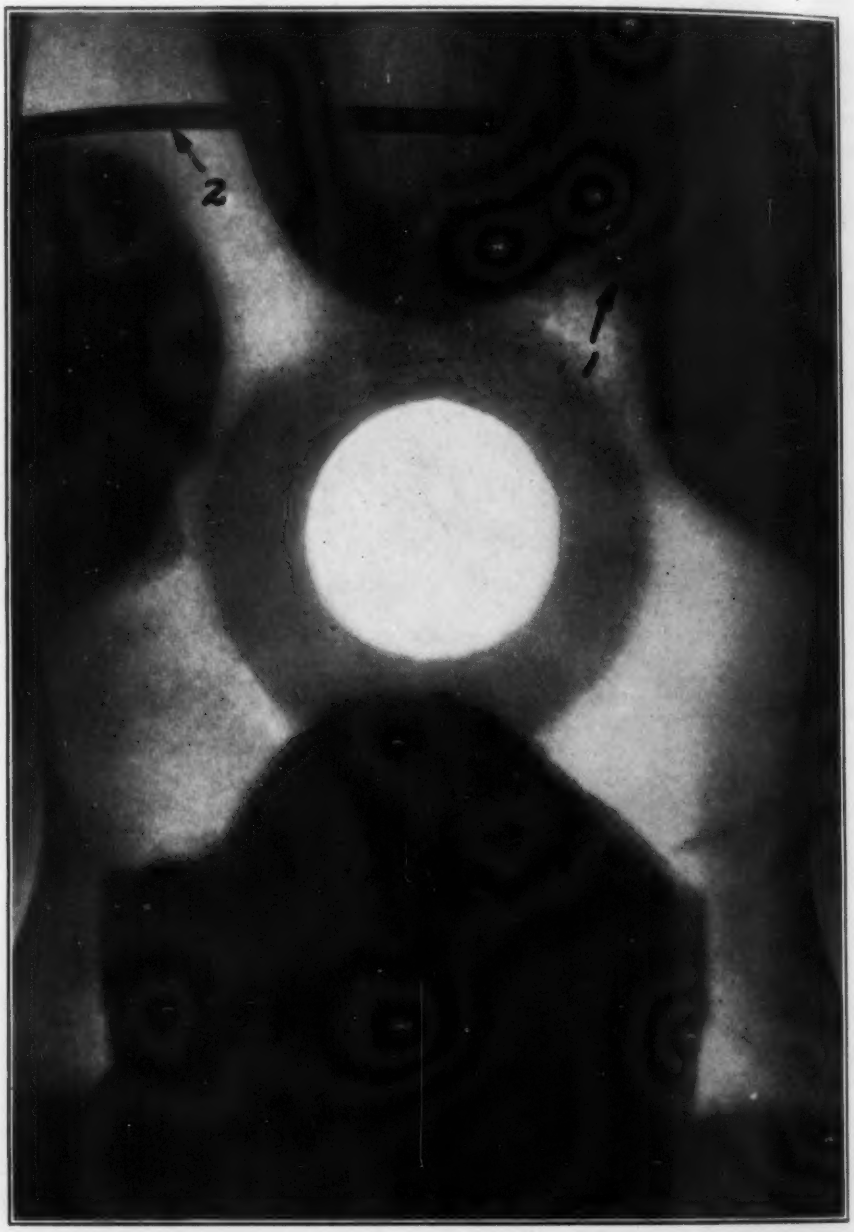


Fig. 21—Part of Water-Cooled Cylinder Head. 1. Edge of Core Sand Which is Indicated by Dark Area. 2. Core Wire.

pieces forged from the ingots. Dross films, fine porosity, and dendritic segregations all appear as laminations on a radiograph taken at right angles to the direction of forging. The various types of laminations were found and located by means of X-rays, and identified by microscopic examination. It was later found to be possible to

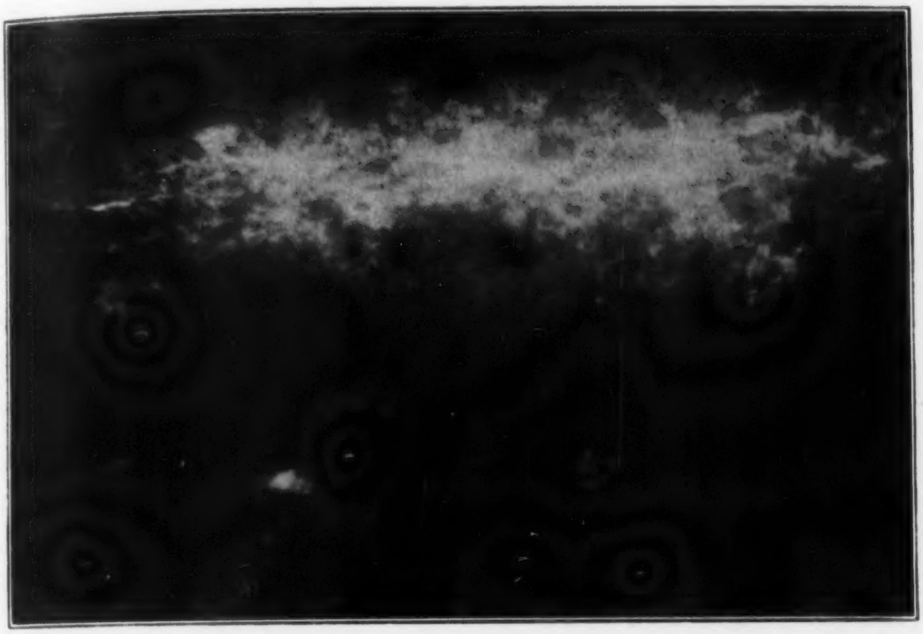


Fig. 22—Spongy Section of Cast Iron Ingot Mold.

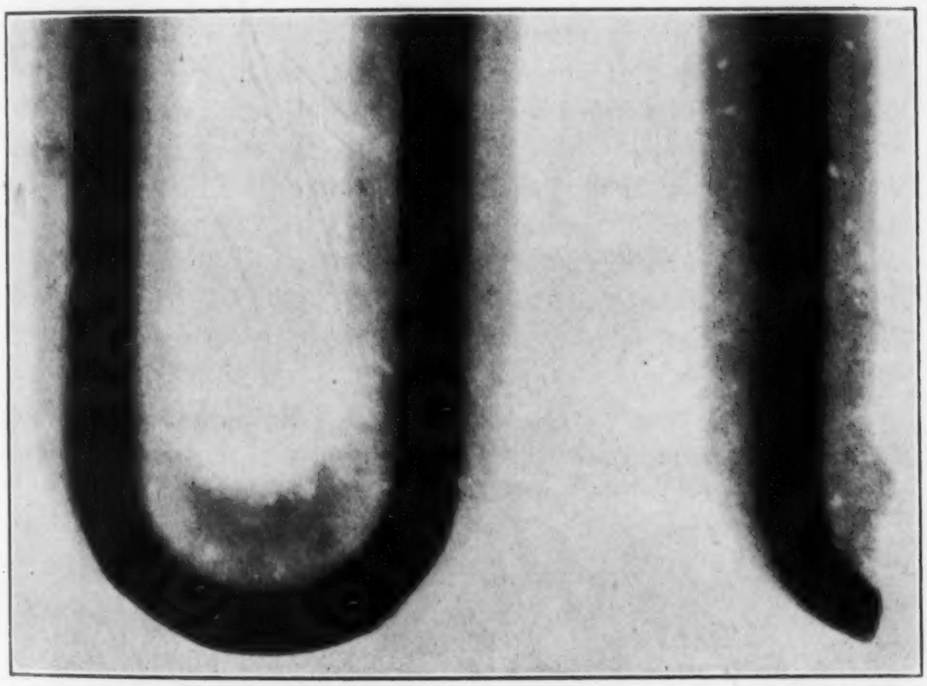


Fig. 23—Shrinks and Porosity in Cast Nickel-chromium Heating Element.

identify the different types of laminations by visual examinations of the fractures of the forged pieces.

At times difficulty has been encountered in trimming certain aluminum-copper alloy sand castings due to the fact that they rapidly dulled the band saws. Prior to the installation of X-ray equipment, specimens from the gates and risers from these castings were examined under the microscope but no abnormality was discovered. The saws had been examined and no defects were found. After the X-ray equipment was installed similar risers were X-rayed and small segregates were located here and there through the section next to the saw cut. After locating them in this manner it was easy to polish a section through a segregate and identify it. The segregates consisted principally of a hard and brittle iron constituent in an aluminum matrix. The structure is shown in Fig. 20.

In a few sand castings with intricate coring X-ray examination has proved valuable in determining whether or not all core sand and core wires have been removed. Fig. 21 shows a section of the cylinder head of a large water-cooled Diesel motor for use on dirigibles. Core sand and core wire are both revealed.

Another use which is of secondary importance at the Aluminum Company but which in other plants might be of primary importance is in the examination of purchased material. A good example is the examination of cast iron ingot molds which are used in making forging ingots. Some of these molds had been found to have a very short life. Radiographs of the cracked regions of these molds showed spongy metal around the cracks as shown in Fig. 22. Some new molds were then radiographed and a record made of the positions of the spongy areas. Cracks developed in these areas soon after the molds were placed in operation. Molds free from such areas gave normal service.

In another case, parts of a cast nickel-chromium alloy heating element overheated in service. It was found that these elements contained numerous shrinks as shown in Fig. 23.

Field of Usefulness of the Radiographic Method of Examination

The field of advantageous use of radiography in the metal industry is of course determined by balancing the costs against the benefits obtained. An analysis of the costs of making radiographs in-

cluding all items (depreciation, labor, materials, rent, taxes, heat, light, insurance, telephone, telegraph, etc.) shows that the cost has been approximately two dollars per square foot of film. These figures are for an average monthly use of 200 square feet of film.

In the case of small parts it is frequently possible to put several parts on one 14 inch by 17 inch film, and thus reduce the cost per piece to well below a dollar. This is less than the cost of the less satisfactory alternative method of sectioning and machining. It is not to be understood from this that the X-ray can completely replace machining tests. If the object of the test is to determine the kind of a surface the customer will obtain on machining, the machining test is the more satisfactory. If, however, the object of the test is to determine the soundness of a highly stressed part, machining is not comparable with radiography.

Another point to be considered is that of time. It is in general much quicker to X-ray a casting than to section and machine it. In some cases such as certain die castings one saw cut will give sufficient information, and it is quicker to section. The time is saved by lowering the standard of the examination.

Another factor which is far from negligible in determining relative costs is the salvage value of the castings after the examination. In approximately 90 per cent of the cases the first casting presented for examination is satisfactory. The casting is returned to the foundry and sold to the customer. If destructive tests had been used, the casting would have been reduced to scrap aluminum.

The cost of complete X-ray examination increases with the size of the casting. In one case the examination cost approximately fifty dollars. In this case, however, information was obtained which could not have been obtained in any other way even at a greater cost and the job which had been given up by another foundry was put on a successful production basis. In other cases it is not necessary to examine the entire casting.

In those few jobs where 100 per cent X-ray inspection was used no other form of inspection could have taken its place. The only alternatives would have been to use forgings, which would require making of dies, or to use a higher factor of safety in the design at the expense of performance, and perhaps at greater net cost.

Most of the radiographic work has been done on highly stressed parts, such as airplane parts, brake shoes, motor parts, etc. In such

parts a very high standard should be maintained by a thorough check of the method before the parts go into production, and there is no doubt as to the profitableness of X-ray inspection.

There are castings which are subjected to low stresses such as ornamental castings, cover plates, etc. In these cases X-ray examination is usually unnecessary, and would increase costs without compensating benefits.

There are parts which cannot readily be placed in one class or the other. Cast cooking utensils, waffle irons, vacuum cleaner parts, etc., are of this type. Such parts have usually been X-rayed only when the usual methods of inspection—visual examination, buffing, fracturing, etc.—have indicated that the castings might not be satisfactory.

Acknowledgement is hereby made to Mr. L. E. Hess who made the radiographs reproduced in this paper and compiled the exposure tables.

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DISCUSSION

Written Discussion: By Dr. H. H. Lester, Watertown Arsenal, Watertown, Mass.

This paper is a welcome addition to a rapidly increasing literature in the field of metal radiography. The authors are to be congratulated.

There seems to be a growing recognition of the value of this method in

developing proper casting technique. Because of its easy penetrability by X-rays aluminum is peculiarly adapted to the method. However, the method may be used to advantage with other metals, particularly steel.

I am not so familiar with the aluminum industry, but steel castings have had to compete with pressed steel and with forgings. Lately a new and very vigorous competitor has appeared in welded structures.

One strong argument for these substitutes for castings is that they are free from hidden defects and are therefore more dependable. Construction engineers are much interested in this characteristic of dependability. They desire to know what is in the metal that goes into a vital structural unit. X-rays furnish a ready tool for inspection. The Atlantic Ocean contains at the present time a number of structural units that failed. It contains also the bones of many intrepid adventurers who trusted to those parts. On the other hand recent history records the startling performance of the St. Louis Robin. I do not know that the metal of the St. Louis Robin was inspected by X-rays, but whatever the method of inspection it evidently was successful in insuring dependability of service. This is just the thing that is sought in castings and is just the thing that radiographic tests will go a long way in securing. It would seem that intelligent use of these tests would be of material help in meeting the strong argument of dependability that is advanced for the various substitutes for castings.

It is also true that the method may be used in improving welded structures to replace castings.

At Watertown arsenal the method has been used recently and with notable success in developing proper welding technique. The procedure is very simple. Experimental welds are made on scrap material similar to that to be used in production. These welds are examined by X-rays and the technique varied till sound welds are produced. This technique is then used on the production job. It is interesting to note that some of the welds that took best on visual inspection may be the worst ones on radiographic inspection. It is also interesting to note that a careful check on the results that have been obtained in production have shown them to be equal to or superior to those obtained in the experimental welds.

We feel that at the arsenal we are taking the uncertainty out of our welding by radiographic testing as we have to a large extent out of our own steel castings. But in this as in the casting work emphasis should be placed on the fact that the most economical use of the method is in developing methods that will produce good material rather than in using it as a tool for rejecting bad material.

Written Discussion: By Wheeler P. Davey, professor of physical chemistry, Pennsylvania State College, State College, Pa.

It is a far cry from the original work undertaken in 1915 to the well-rounded body of information given in Fink and Archer's paper. The basic principles of the original technique, such as the lead backing for the photographic film and the mask for the specimen remain unchanged, but the use of barium clay, lead shot, and dense solutions is a great improvement over the old lead masks. The filter screen takes the place of the old technique

of using only a narrow cone of X-rays in the effort to reduce the effect of secondary rays.

The exposure curves for aluminum, magnesium and iron specimens surpass in completeness anything that was ever attempted during the pioneer period.

With commendable frankness, the authors bring out the fact, previously emphasized by Lester, that there are few cases where it is good economics to use radiography for 100 per cent inspection. This is in refreshing contrast to the attempt by Glocker in "Material Prüfung mit Rontgenstrahlen," to show by means of a poor system of cost accounting how cheap the method is. As a method of developing foundry and welding technique, radiography is amply justified and in the hands of Lester, Fink and Archer has gone considerably beyond the dreams of 1915.

Written Discussion: By E. E. Smith, Eastman Kodak Company, Rochester, N. Y.

After reading this excellent paper with a view of preparing a discussion, our impression is that the many points have been treated so fully that there is nothing much left to discuss.

Since my connection with this subject is principally photographic, it would seem pertinent to confine my discussion to that phase of the subject.

It is the desire of course of all manufacturers using this method as it was with doctors employing X-rays in the examination of the body to do the work fluoroscopically, rather than photographically. This would be cheaper, quicker, and more convenient, but it has decided limitations which the authors have pointed out.

Fluorescent screens are widely used in conjunction with the film by the medical profession and to some extent in the metal industry. A faint blue light is emitted from these screens to which the film is much more sensitive than the eye; and, of course, this light has an additive effect on the film during the entire exposure.

To increase the illumination on the fluoroscopic screen for visual inspection, the grain size of the fluorescing salt has been increased, so that one is confronted in the fluoroscopic examination of metals by two very serious handicaps—a very low intensity of illumination which requires the observers' eyes to be accommodated to darkness and a coarse-grained image—neither of which lead to the easy detection of the fine detail which is desired in this work. So, as the authors state, this examination is suited only to thin specimens where the features to be detected are comparatively large, and even under these conditions, untrained or careless inspectors will pass parts which show flaws of considerable size when they are radiographed.

In the work of metal radiography, we are handicapped with one thing which gives practically no trouble in medical work except in the heavier parts of the body,—namely, secondary or scattered radiation.

The authors have gone into this subject in detail and given the various methods of blocking and screening out this radiation. The simplest and easiest way is with the use of metal screens, which are very effective against the secondary radiation which strikes the film at small angles. Even a thin metal

screen will absorb a large percentage of this radiation when the incident angle is small, while the more penetrating primary ray which is traveling nearly perpendicular to the screen will be only slightly absorbed.

Thus the foil method of screening out secondary radiation is most efficient in radiographing small objects or a group of small objects, where a considerable portion of the film is not covered and receives the full primary radiation. When an excess of radiation strikes the film covered only by the exposure holder or cassette, it tends to spread out in all directions and creeps under the object being X-rayed and blocks the detail in the finished negative. But if the object being examined completely covers the film, there will be very little radiation of this type.

In the case of thicker sections, however, there will be considerable scattered radiation from the object which will tend to strike the film at all angles and against this the metal screen will not be as effective. In such cases the Bucky diaphragm serves this purpose better. The Bucky diaphragm absorbs only about 10 per cent of the primary radiation and absorbs the scattered radiation through a wide range of angles.

The Bucky diaphragm used in medical work will operate only for a few seconds without resetting, which renders it unsuitable for metal work where the exposures are of some duration. However, there is one made in Sweden by Jarnhs Elektriska Aktiebolag of Stockholm, designed by Dr. Akerlund which will operate continuously. This is known as the Akerlund diaphragm and differs from the Bucky in that the lead strips are placed in spiral form from a common center rather than straight parallel bars. The fact that this diaphragm may be set to rotate throughout the exposure makes it more adaptable to this type of work.

The Bucky should be very effective with aluminum and the lighter metals but its value with the heavier metals has not yet been determined. It might be necessary to use a heavier lead strip than is now employed. This would mean a higher absorption of the primary ray and longer exposures but the results would probably warrant this increase in time in many cases.

The authors mention the use of double exposures to definitely locate defects with respect to depth or distance from a known point.

In stereoscopic vision the eyes and brain automatically locate the relative positions and distances of objects from the observer. No thought or calculation is necessary and for this reason the stereoscopic method would appear simplest and most satisfactory for locating relative positions of flaws in the object.

If desired the positions of the parts of an object can be accurately determined from stereoscopic photographs from the knowledge of the tube shift, target film distance, and the shifts of the images on the film. In medical radiography, experience shows that fine fractures and other details show up more clearly in stereoscopic than in single views.

As the authors contend, the development of the radiograph is a simple process. We have been consistently working to have the developing of X-ray film reduced to mechanical processes in the various clinics and hospitals. We have determined that the best photographic quality is obtained when the films are so exposed that they will be fully developed in five minutes at 65 degrees

Fahr. Suitable changes in the developing time to compensate for variation in the temperature of the developing solutions is made. This system should be easier to install in X-ray laboratories working with metals for the required exposure can be more accurately determined for the various thicknesses of these materials.

Such a developing system does away with the personal equation and in judging photographic development in a dark room this is a factor to be considered. Where our time-temperature method of development has been employed it has lead to better and more consistent results than the other methods.

All X-ray negatives because they have been designed to give a maximum of contrast do not make good prints as easily as the other photographic film. In producing copies of these negatives either for lantern slides or prints it is best to first make an intermediate positive on portrait film. If this film is slightly overexposed and underdeveloped a slide or print of good quality can be made from it and there will be the added advantage of obtaining in the finished slide or print the same densities as the original—or in other words, it will be a negative rather than a positive and will be more easily read and understood.

In closing I would like to compliment the authors on the excellence of this paper as a whole. The subject has been very thoroughly treated and they have made very clear the technique necessary to produce good radiographs, together with the limitations and practical value of X-ray examination.

They have shown that even though it appears expensive it is often a means of effecting great savings in manufacturing and in certain cases may even be used profitably in a routine examination of products.

There is no doubt that the many possibilities of such a method of examination have not been properly realized and appreciated and we feel that as soon as the manufacturers more fully understand just what can be done with X-rays in detecting hidden flaws, there will be many such installations made by various manufacturing plants.

Written Discussion: By Ancel St. John, Ph. D., consulting physicist, New York.

This paper is particularly welcome to me. As many of you know I have for some years been urging the use of X-rays in the metal industry. Too often my words have been looked upon as propaganda from one who has an ax to grind, and have been heavily discounted. Hence this evidence of the real value of radiography, coming from a satisfied user, is most gratifying.

I have been rather interested in the exposure charts. At my laboratory I have been using the ordinary duplitized films, double intensifying screens, Coolidge tube and a 200,000-volt power plant in the routine examination on a commercial basis of materials ranging from old paintings to heavy steel castings. On the latter I have been securing satisfactory pictures through 3 inches of steel at 21 inches distance in 30 minutes using 4 milliamperes. This is much more rapid than anything shown in the charts.

In using filter sheets as described at the top of page 563 I find it desirable to place them just in front of the film so as to absorb as much scattered radiation as possible. I also find it preferable to use material having absorption characteristics similar to the material under examination, i. e., aluminum for mag-

nesium or aluminum, copper for iron, steel, copper or brass. Otherwise much of the finer detail may be suppressed. With this procedure a filter which doubles the exposure time gives excellent pictures without suppressing very much detail.

I no longer recommend the use of methylene iodide as an absorbent liquid. It is too expensive, too active in attacking metals and has a too persistent odor. In its place I recommend a lead acetate, lead nitrate solution. It was first used on some small brass castings and has been regular routine in my laboratory for more than two years. There is little or no corrosive action on steel, iron or brass. I have specimens which were immersed for several hours 18 months ago and then merely rinsed with hot water and drained. These show no signs of attack.

Written Discussion: By L. W. McKeehan, Sloane Physics Laboratory, Yale University, New Haven, Conn.

The paper by W. L. Fink and R. S. Archer is a notable contribution to the literature of X-ray metallography. In the examination of light metals in all thicknesses and of iron and steel in thin sections the method is now well-established but the details of technique have been for the most part described only in widely separated and relatively inaccessible papers. The splendid bibliography here included will substantiate this statement and is in itself of great value. The illustrations are wisely chosen and clearly explained. It is, of course, impossible to show on the printed page all the detail than can be seen in a good photographic negative, so that the difference between good and bad specimens may not always strike the eye of the reader. An example is to be seen in Fig. 19 where it may be a matter of some doubt which cut represents the better casting.

The development of fine-focus high duty X-ray tubes has of late years hardly kept pace with the demands of radiographers but there is hope of further great advances. A very recent note by Müller (*Nature*, Vol. 124, p. 128, July 27, 1929) describes a tube in which over-heating of the focal spot is prevented by placing it on the rim of a rapidly revolving water-cooled disk. Cooling methods, however drastic, cannot prevent rapid deterioration of the target when tubes are pushed to their operating limit and the cost of ready-made tubes is an important part of the total cost of radiography. In other countries there is a tendency to use continuously pumped X-ray tubes with demountable targets and cathodes, thus making the cost of replacement less, although the cost of skilled labor needed for successful maintenance is rather greater.

Written Discussion: By John T. Norton, Jr., Massachusetts Institute of Technology, Cambridge, Mass.

I have read with much interest, the splendid paper of Messrs. Fink and Archer, on the subject of radiography and it is pleasing to learn of the practical success of this method of examination in the field of light metal. The paper is an excellent and complete exposition of present day radiographic practice and discusses not only the advantages, but the limitations of the method.

Several points have been brought out which are of considerable interest to users of X-ray methods. The question of the use of metal screens for filtering and intensifying is very important. Some work has been done in this connection, but much more is needed, for the ordinary straight-forward methods have about reached their limit as far as quality of radiography is concerned. It is only

by some such development as this that further improvement will be possible. Another point which has an important bearing as we gradually go to greater and greater thickness of sample is the fact that defects close to the film side of the object are practically the only ones visible in thick samples. Even if X-ray equipment of 500,000 or one million volts were available, this effect of internal scattering in the sample offers a serious obstacle.

It seems almost essential for further development of this method of examination that a more sensitive device replaces the photographic material now so generally used and one which is more flexible in its application. Perhaps it will be an ionization or a photoelectric device but whatever its nature, it is badly needed and merits a good deal of serious study.

The figures on the cost of making radiographic examinations are quite interesting and agree in a general way with those obtained in the writer's laboratory. While he objects somewhat to the basing of costs on the area of film used, he realizes that most of the other methods of rating have similar objections. Each problem requires a separate estimate.

The authors are to be congratulated upon an excellent and interesting piece of work which should be very valuable to those contemplating the use of X-ray methods. It would be most interesting now to have a similar account of the practical application of the method in the iron and steel industry, for the problems though similar are somewhat different.

Written Discussion: By E. W. Page, Victor X-Ray Corporation, Chicago.

I wish to express my appreciation to Dr. Fink and Mr. Archer for the remarkable work that they have accomplished. It is my belief that their remarks regarding this work should only be of a commendatory nature. Although this paper has confined itself to the radiographic application of X-rays to their problem, the fluoroscopic method has been mentioned both to its advantages and limitations. It has been our experience that the advantages gained in speed and economy are confined to materials of lower atomic weight and assemblages of materials with wide variations in atomic weights and only in routine inspection where the gross imperfections are the only ones, that give concern and where a means of preventing secondary radiation is eliminated by the specimen itself, or an arrangement built in the fluoroscope. In most other cases we have found that there is little gain, if any, in this method of inspection due to the inability of obtaining a satisfactory diagnosis from a fluoroscopic screen caused primarily by the characteristics of the screen itself, which offers lack of detail, due to the size of crystals necessary in the material used for this screen, and the lack of contrast exhibited where very small imperfections are the ones under consideration.

The simple geometrical relations as exhibited in Fig. 2 of the paper offers valuable information in order to arrive at satisfactory diagnostic radiographs. Since the size of the focal spot is definitely fixed in X-ray tubes and since the normal eye can detect nothing less than 0.01 of an inch of shadow or distortion, the graphical relations offer a simple means of calculating the distance of the focal spot from the material and film in order to produce a radiograph that will show differences in densities within the normal vision.

Our experience in radiography has proven to us that secondary radiation

must be properly taken care of in order to produce satisfactory radiographs. The typical method exhibited in this paper of blocking our secondary radiation is, no doubt, satisfactory. It has been our experience that where we have different thicknesses of materials, where possible, there should be a complete blocking of all radiation striking the film from the thinner sections and we have found that in order to accomplish this, an absorber, such as sheet lead, should be placed as close to the film as possible underneath the thinner sections so as to prevent the secondary radiation from the lower side of these thin sections striking the film. It has also been our experience not to place any other material underneath these thin sections unless it completely absorbs all radiation striking it. Material of lighter atomic weight than the specimen being radiographed offers another source of secondary radiation which we find detrimental.

The exposure curves here published and the ones that we have compiled and those of previous authors show some variations. The differences in variations between the charts of this paper and the ones that we have compiled, are very slight and is probably due to the fact that we are satisfied with a lighter exposure. The variations exhibited between the charts in this paper and the charts from a different origin is probably due to the different methods in eliminating the secondary radiation which causes so much confusion. Nevertheless, these charts offer a key to satisfactory radiographs.

The different methods used for localization of defects are quite necessary for the many problems that exhibit themselves. It is true that drawings are read with projections at 90°, but there are many times where a radiograph cannot be made at 90° from the original and for this reason, I believe that there has not been a sufficient amount of emphasis placed on the stereoscopic method where two radiographs can be viewed with a stereoscope and the imperfections or whatever is involved can be viewed in the third dimension and its definite relation established to any of the existing planes.

The industrial applications expounded by the authors are very interesting and their results should be very gratifying. There is one thing in our estimation that requires emphasis and it is gratifying to find it referred to in this remarkable paper, and that is, the assurance of a uniformly high quality of experimental samples. It would seem as indicated that for authentic information derived from experimental work, that it should be necessary to have sound materials and it would seem just as important as having a correct chemical analysis of the material. It is this phase that I believe opens up a very important field in metallurgy, for too often have we had the experience of radiographing samples that have failed from other causes than the characteristics of the material itself. We have also found where materials have failed and sections taken to arrive at the cause of failure that the information obtained from the sections in no way contributed to the cause of this failure, principally because the section was not taken and included the necessary evidence. X-ray, apparently, at this time, will never relieve the necessity for physical tests but it will certainly aid in arriving at more authentic evidence in co-ordination with the physical tests. I recall an instance where a weld had been sectioned and exhibited but two small holes. It was apparent from this sectioning that the weld was satisfactory. Radiographically, the condition of this weld was more like

a sponge and would certainly be imperfect and it is such things as this that offer themselves for future investigation and development.

In closing, I wish again to extend my compliments to the authors of this exceedingly interesting paper.

Note: Since I have the opportunity, I wish to voice my criticism, not of this paper alone but of the majority of publications on this subject of X-ray as applied to various industrial problems. It is beyond me why the authors of such papers allow illustrations to be published in the positive rather than in the negative, realizing that all examinations of radiographs are made in the negative and to publish them in the positive is very confusing, especially when the author speaks of dark spots and the illustration shows them white. I believe it progressive to this art and I hope that in the future, that the authors of such papers will see that their illustrations are published in the negative as they are examined.

Oral Discussion

Dr. W. P. Davey: Mr. Chairman: Dr. Lester has kindly corrected one statement that I have made, and I would like to pass the correction on. He tells me that his earliest work on steel went up to 3 inches in steel which was a much greater thickness than I thought he had taken in the times I had in mind.

E. W. Page: There is one other thing that has been brought to my attention in one of the other discussions regarding the use of filters. A few years ago, when I developed the method now being used as the filtering method, the sheets of lead were placed in contact with the film. Dr. St. John stated that he obtained better results with them as close to the film as possible, due to absorbing more characteristics or more scattered radiation. That amount of lead will only absorb a definite amount regardless of its position and the reason why the lead filters were put in contact with the film was to prevent the secondary radiation from the filter, fogging the film and utilizing this secondary radiation from the filter as an intensifying factor.

Authors' Closure

We thank those who have contributed to the discussion. A few points have been raised upon which we wish to comment.

In regard to the exposure curves, the values given represent what we consider to be optimum exposures for the conditions used. They are not intended to represent the minimum time in which an exposure could be made. The optimum time varies according to the amount of filtering that is used. The more effective the blocking and screening the less the secondary radiation, the less the fogging, the longer the exposure which can be used advantageously and the better the film that is obtained. The minimum time in which an acceptable exposure could be obtained would be considerably less than the optimum by an amount which would depend upon the type of work and upon the judgment of the operator.

The speed of the intensifying screen varies from screen to screen and with the age of the screen. This would, of course, have an effect upon the exposure time. In the case of the lead filter screens the thickness of the screen would affect the value.

The type of specimen has a decided influence. In compiling our exposure data only wrought samples and very sound castings were used. Porous or spongy castings would, of course, give smaller exposure values. It was not intended that these curves would be used without any alteration, but it was felt that they would serve as a guide to those who install X-ray equipment in the future.

In regard to the filter screens mentioned by Dr. St. John, he says that he finds it is better to place them next to the film. In all of the work which we do using filter screens the lead filter screen is placed in the cassette next to the film. The filter which is used next to the tube is a secondary filter. It would seem rather awkward to place next to the film a filter screen of the same material as the specimen and of sufficient thickness to double the exposure time.

Mr. Page states that in blocking out the radiation from the thinner sections of the specimen, the sheet lead should be placed as close to the film as possible. This is in agreement with our experience.

IMPROVING OF REFRACTORY LINING OF HEAT TREATING FURNACES FOR HIGH TEMPERATURE ANNEALING OF STEEL CASTINGS

By William J. Merten

Abstract

The paper discusses the use of a highly refractory glazing for a protective coating to be applied on ordinary firebrick furnace wall surfaces for high temperature annealing of large section steel castings or forgings. It points out the directions for improvement of furnace linings in annealing practice in steel foundries to permit complete exploitation of potential physical characteristics of large cast steel parts by thermal refinement at high temperatures. It also contains a description of a method of coating steel castings for protection against excessive scaling invariably encountered when exposing steel to such elevated temperature for long time periods.

THE employment of high temperatures above 2000 degrees Fahr. (1095 degrees Cent.) for refinement and readjustment of grain structure of large-section steel castings compels the consideration of a furnace lining of decidedly greater refractory characteristics than those ordinarily employed in steel foundry annealing equipment. The ordinary firebrick or silica brick bonded with fireclay devitrifies around 1900 degrees Fahr. (1040 degrees Cent.) and is not satisfactory for use even for intermittent exposures to 2000 degrees Fahr. (1095 degrees Cent.) and above because of rapid deterioration. Its resistance to spalling and crumbling is low after only a single exposure to this temperature.

A magnesite brick lining would obviously avoid this difficulty. Its cost, however, is a serious objection and would retard progress towards a general application of high temperatures for the heat treatment of steel castings.

The conversion of the ordinary firebrick lining into one of high refractory character by a simple spray coating of a refractory glaze is of course very desirable. The successful selection of such coating

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A paper presented before the eleventh annual convention of the society, Cleveland, September 9 to 13, 1929. The author, W. J. Merten, member of the society, is metallurgical engineer with the Westinghouse Electric and Manufacturing Co., East Pittsburgh. Manuscript received June 10, 1929.

naturally reacted very favorably toward the adoption of the rather unusual practice.

A careful survey of the refractory glazes used in the high voltage porcelain industry offered the solution to the problem in a glaze used for porcelain shields. This glazing compound is an aluminum-calcium-magnesium-iron silicate known to the trade as "Albany Slip." A typical composition is as follows:

	Per Cent		Per Cent
H_2O	1.72	Fe_2O_3	0.82
Loss on Ignition	8.05	P_2O_5	0.19
SiO_2	60.80	Ca	8.78
Al_2O_3	10.54	Mg	2.91

The finely ground powder suspended in water is sprayed over and into the brick sidewalls and cover of the furnace and left to dry, care is taken that all crevices, cracks and openings are thoroughly covered. The glazing takes place at a temperature just below 2000 degrees Fahr. (1095 degrees Cent.) so that it becomes necessary to raise the heat of the furnace or heating chamber to at least this temperature. The glaze which covers the entire surfaces of the heating chamber as a continuous sheet converts the chamber into a heat reflecting and heat radiating body of a very high efficiency practically sealing the chamber against excessive heat loses through porous brick lining and crevices to the outside. This preservation of heat or reduction of heat losses is so marked that it actually results in a reduction of total time for raising the temperature of a charge to this high temperature even below that needed ordinarily to heat the same charge to 1750 degrees Fahr. (955 degrees Cent.)

The appearance and durability of the brick lining is well illustrated in photograph, Fig. 1 showing the glazed surface of a brick and indicating the thickness of the glaze. Cooling to room temperature results in rupture of the glaze into fine fissures and small craters on the surface which heal and close up again on subsequent heating. The continuous reheating and reglazing brings about a lowering of the glazing temperature due to an enriching in silica content which is a decided benefit up to a point when the composition is changed to a degree that may induce spalling. It is, therefore, advisable to respray periodically after several heats. Gradually the entire brick lining will change to a quasi porcelain consistency which may be too brittle to be of further service. However, to date, after quite some length of time, no difficulties have been encountered, see Figs. 2 and 3.

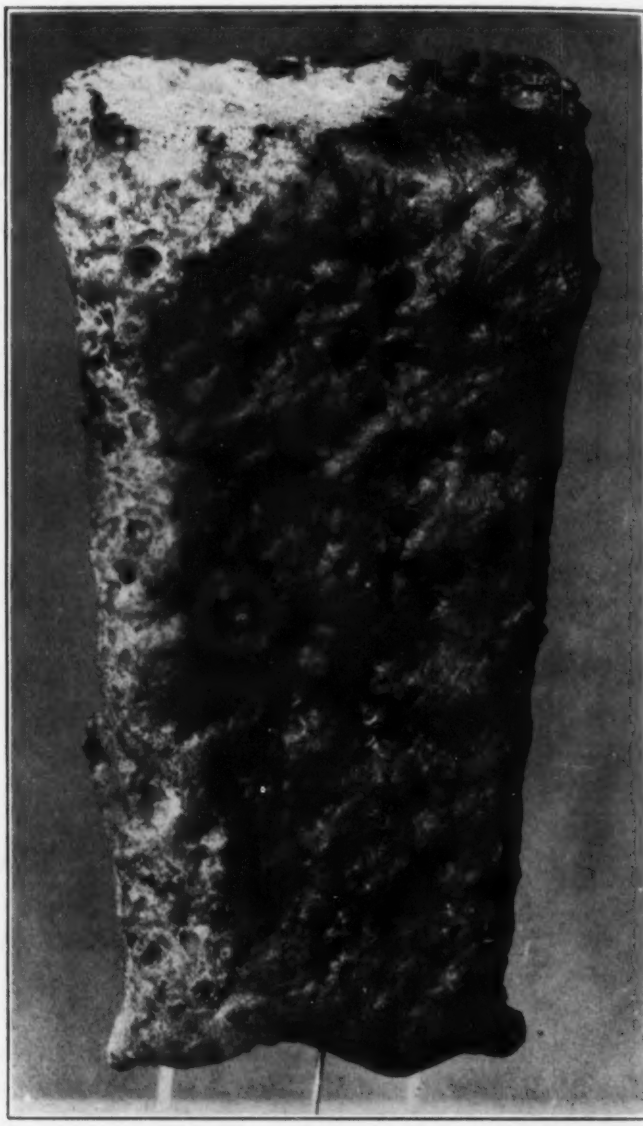


Fig. 1—Showing Glazed Surface of a Refractory Brick.

The benefits derived from this glazing of the furnace chamber wall surfaces are first of all saving in fuel cost; second, more uniform heat distribution and consequently more uniform heating of the charge; third, less scaling since convected heat through circulation of gases always furnishes a fresh supply of oxygen and consequently favors oxidation more than heating by reflection or by radiant heat transmission; fourth, checking of furnace temperatures with radiation or optical instruments was an inconvenient and even dangerous

Fig. 2—Refractory Brick Showing Diffusion of Glazing Into the Surface.

task on account of the intense heat of the outside furnace wall surfaces. The more perfect heat insulation of the glazed heating chamber made this work considerably less difficult. Last, but not least, economy from reduction of cost of maintenance of lining is of considerable importance.

Protection of Steel Castings Against Scaling and Oxidation

The coating of steel surfaces for protection against scaling at high heat is usually defeated by a peeling or spalling of the coating upon drying, due to lack of bonding material. Any oxidation that may occur reacts to expel the coating rather than as a bonding constituent. The use of soapstone or talc in a finely powdered condition preliminarily applied, solves this difficulty in a practical and easy

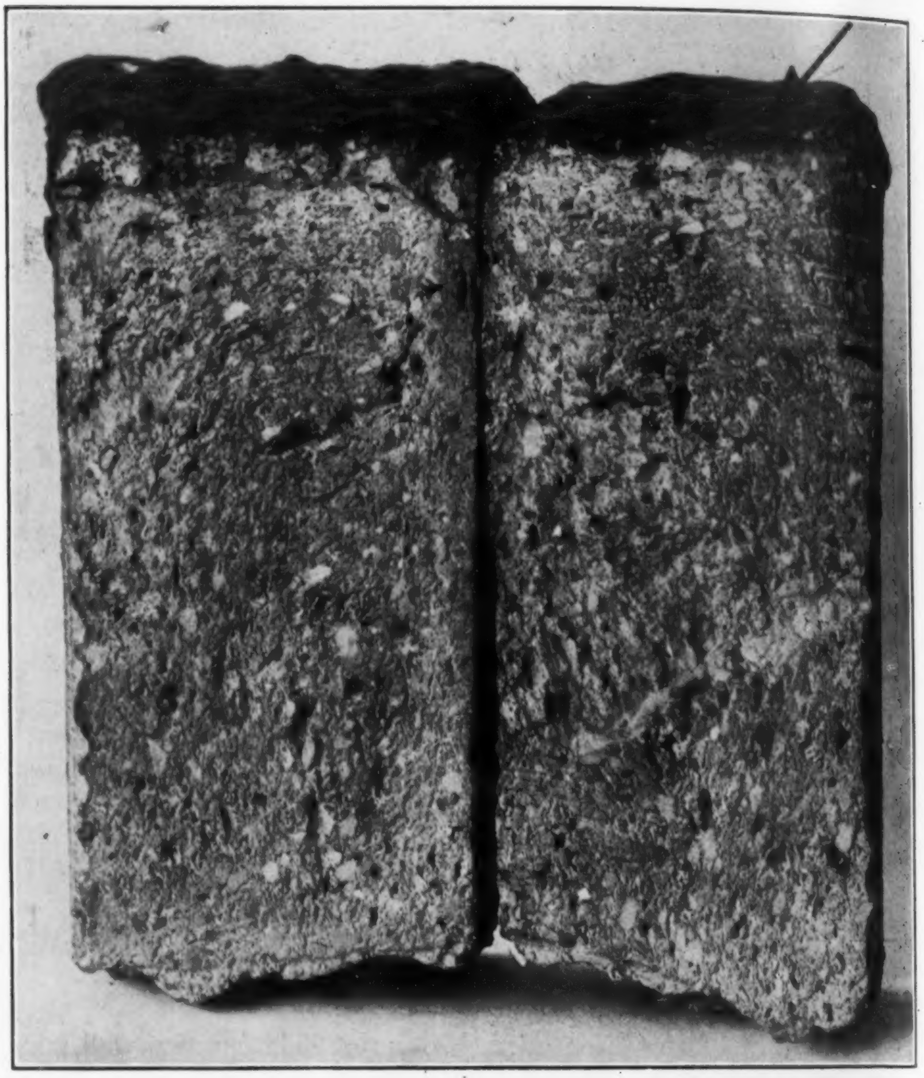


Fig. 3—Cross-section of a Refractory Brick Showing Diffusion of Glazing.

manner. The clinging tendencies of soapstone are well known and the coating itself, however thin, is a protection in itself and a fairly satisfactory base coating for further application of the glazing mixture.

The ease with which the glaze solved the problem of protecting the furnace lining against deterioration from heating to the high temperature suggested its use also for the solution of the problem of preventing excessive scaling when exposing steel to the high heat. Obviously the plain water-suspended powder is not applicable since the nonporous steel surfaces do not provide an anchoring

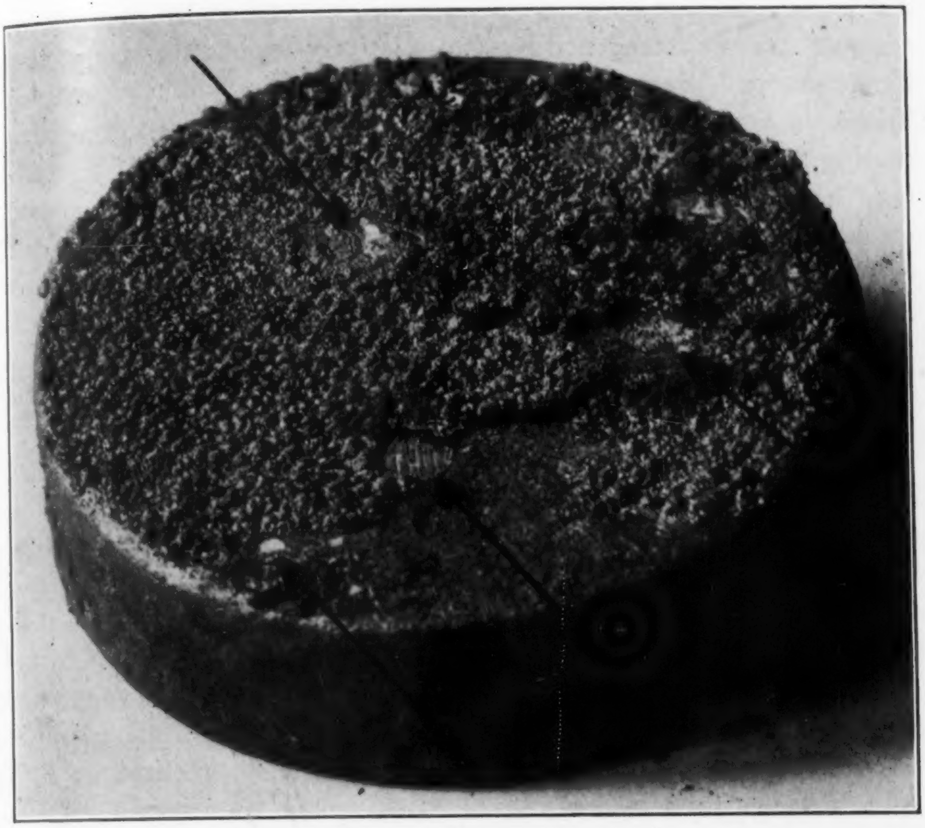


Fig. 4—A 4-inch Disk Fired Under an Oxidizing Condition and Held at 2300 Degrees Fahr. for 3 Hours. Bright Spots Show Preservation of Original Surface.

for the powder upon evaporation of the water. The finding of a bonding material to hold the powder up to its glazing point became the problem to solve. Sodium silicate naturally suggested itself, however, it could not be used alone since its swelling on drying and fusion gave a porous coating. A combination of lime-borate mixed with a dilute sodium silicate, water solution and glaze gave the results wanted and a nearly hermetically sealed steel body can be produced which gave little loss from scaling. There is, however, a slight chemical scoring effect on the surface so that such a film cannot be used for bright annealing of steel. The removal of the glaze after heat treatment solved itself automatically, the cooling in air from the first heat loosens the glaze and produces cracks which are not again closed. Reheating for grain refinement at 1650 degrees Fahr. (900 degrees Cent.) results in a slight scaling through the cracks and fissures which loosens more of the still clinging portions; another cooling in air following this normalizing heating practically frees

the steel from the rest of the glaze. Reheating for removal of residual stresses introduced by comparatively rapid air cooling leaves the castings practically clean with only a lightly clinging thin scale covering of Fe_3O_4 which is somewhat of a rust preventing coating and of benefit during transportation and storing of the castings in the open, which is the usual procedure with large castings until machining operations can be started. Fig. 4 shows a 4-inch steel disk fired at 2300 degrees Fahr. (1260 degrees Cent.) for about 3 hours in an open fire gas furnace chamber. Scaling on an unprotected surface under such conditions is very heavy. In this case the surface has scarcely been attacked. A quick drying seems to produce the best coating and torch drying may be advantageous.

In concluding it should be stated that the cost of the materials employed in this work is small indeed. The glazing compound in liquid form costs only a few cents per gallon, while scrap soapstone, lump and powdered, costs about $14.00 per ton. The material cost per casting or forging is practically nothing and certainly less than $0.05. The labor cost of applying is the only item worth consideration, although this is certainly less than the cost of removing scale. Brushing on of soapstone powder and spraying on of the glaze on the steel casting surface are probably the most practical ways to apply the coating.

Written Discussion: By Fred G. Frisbie, Duquesne Steel Foundry Company, Pittsburgh.

I can corroborate Mr. Merten's remarks concerning the efficacy of a porcelain glaze on a firebrick furnace lining. It has been due to his cooperation that we have been able to employ temperatures between 2000 and 2200 degrees Fahr. on large section steel castings without having extensive furnace repairs.

We apply the aqueous suspension of "Albany Slip" either by brushing or by spraying, as suggested in this paper. Apparently this material is of benefit at temperatures as low as 1700 degrees Fahr., although the glaze is not formed until 1950 or 2000 degrees Fahr. is reached. The reflection of heat by the brick work so treated is in such a degree that it is possible to stand on the covers of the furnace for a period of several minutes when the inside the furnace is as high as 2200 degrees Fahr. without undue discomfort.

An excellent feature of the glazed brickwork, which might be inferred from Mr. Merten's paper, although not mentioned by him, is the more perfect heat balance obtainable between furnace walls and castings. This balance at times becomes so nearly perfect that it is impossible to distinguish the casting.

I have successfully protected smaller castings against scaling using a water suspension of glaze over a thin coating of soapstone. No lime-borate or sodium-silicate was used, as recommended in the paper.

ECONOMICAL RE-USE OF SOLID CARBURIZING MATERIALS

By H. B. Knowlton

Abstract

This paper discusses a study of the re-use of carburizing materials with particular reference to the amount of new material which should be added after each carburizing run in order to maintain a constant volume and a constant activity of carburizing compound. Methods of handling which minimize mechanical losses, and methods of screening and mixing which assure a uniform dustless material, are described.

An analysis is given of the changes in composition which may take place during the use of a carburizing compound. A method for determining the limits of composition for a mixture of old and new material, is described. It is also shown that by practical application of the principles given in this paper a large saving in cost has been effected.

In commercial case hardening with solid carburizing materials it is the usual practice to use the same carburizing material over and over with the addition of a certain amount of new material after each run. If the production of case hardened work remains constant, the real cost of the carburizing material is proportional to the amount of new which is added after each run. In spite of the fact that this is a vital factor in the cost of carburizing, there seems to be a wide divergence in the practice in different places, even when the same carburizing material is used. The additions of new material after each carburizing run, vary from 10 to 50 per cent. In fact some hardeners believe in using 100 per cent new material on certain classes of work.

For the past two years the writer has been studying this problem to see what could be done to decrease the per cent of new material added after each carburizing run, without changing the carburizing temperature or time cycle, and without decreasing the quality of the

A paper presented before the Eleventh Annual Convention of the Society at Cleveland, 1929. The author, H. B. Knowlton, member of the society, is metallurgist, International Harvester Co., Fort Wayne, Indiana. Manuscript received July 3, 1929.

carburized work. Two years ago the addition of new material amounted to about 33 per cent. By making certain changes in the composition of the carburizing material and the method of handling it has been found possible to reduce the amount of new additions from 33 per cent to about 12 per cent. At the same time daily tests have shown no decrease in the depth of the case nor the per cent of carbon in the different zones. As all of the carburizing was done in a modern automatically controlled counterflow furnace it is believed that the results found on the test pieces accurately represent the carburizing of the production work. Whether it will be possible to continue indefinitely on a basis of 12 per cent new additions or whether further study will bring about even greater economies, only time can tell.

Functions of New Additions

The first point to be considered is, why are additions of new material after each heat necessary? What useful functions are performed by the new material? If the production of carburized work is constant and there is enough carburizing material of the desired activity on hand for a single day's run, then additions of new material on the following days are required for two purposes only:

1. To maintain a constant volume.
2. To maintain a constant carburizing activity.

Loss of Volume During Use

All carburizing materials necessarily decrease in volume in greater or less degree during use. The amount of loss of volume, however, may often be greatly decreased without any harmful effect upon the carburized work. A study of these losses is helpful in solving the problem. Volumetric losses are due to the following causes:

1. Burning or decomposition during carburizing
2. Burning during direct quenching
3. Burning after dumping, on the floor or in bins, hoppers, etc.
4. Removal of dust and fines
5. Mechanical handling.

While the losses produced by some of these causes are unavoidable, other losses may be eliminated or at least reduced to a minimum.

The loss due to burning in the carburizing container depends not only upon the temperature and duration of the carburizing heat, but also upon the type of carburizing material and the type of container employed. Cracked or poorly sealed containers may be responsible for excessive losses. Inverted alloy boxes probably help minimize losses.

The value of the direct quench upon the structure of the steel will not be discussed. From a cost standpoint it may be better to cool slowly in a counterflow furnace, thereby decreasing the loss of the carburizing material and reducing the costs of heating and carburizing containers. When direct quenching is employed, some believe in sprinkling the carburizing material with water after dumping to cut down the loss by burning. Burning of the carburizing material in the bins, hoppers, or in the handling system is certainly unnecessary and expensive.

Some men believe that it is unnecessary to remove the dust after every run. The present writer holds that dust and ash never perform a useful function and frequently cause poor carburizing, and consequently should be removed. The dust is composed of ash formed by burning of the carburizing material, fines produced by burning and crushing, and chemical separated from the base material. It may also contain such extraneous contaminations as dust and dirt from the floor, sand from a nearby sand blast, and small particles of clay and scale. Of the whole list only the ash and the fines produced by burning should be classed as legitimate. One of the most frequent causes for the production of dust and the consequent loss in screening is the crushing action of rough handling.

It may be difficult to differentiate between the losses taking place during actual handling and the additional loss during removal of fines which is due to the crushing action of rough handling. It may be surprising to learn how large these two losses sometimes are. Certainly they should be eliminated.

Tests on Shrinkage During Use

In order to determine the loss of volume during use, tests were run on several different carburizing materials, or "compounds" as they are commonly known. (The term "carburizing compound" is really a misnomer from a chemist's viewpoint, but it is so commonly used that it is employed here). The results of two of these tests are shown by the curves in Figs. 1 and 2.

In each of these tests two carburizing boxes were loaded with steel and carburizing material in the usual way. One test pin was placed in the top and one in the bottom of each box. Accurate weights were kept of the boxes, covers and all of the materials placed in the boxes. The boxes were run through an automatically controlled counterflow carburizing furnace. The conditions of carburizing were exactly the same as those encountered by regular production

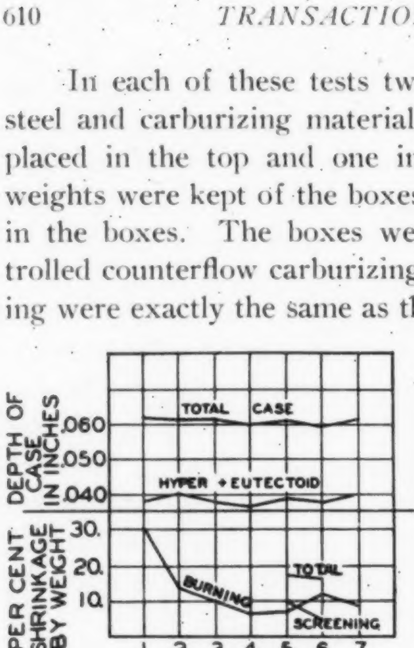


Fig. 1—Curves Showing Depth of Case and Shrinkage. Original Mixture was Charcoal and Chemical. Enough New Material was Added After Each Run to Make up for Shrinkage.

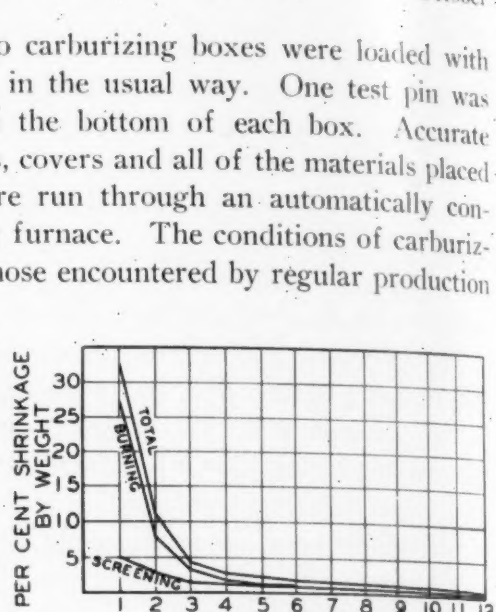


Fig. 2—Curves Showing Results of Shrinkage Test. Original Mixture was Charcoal, Coke and Chemical. Enough New Material was Added After Each Run to Make up for Losses.

work. At the same time the control was so good that for all practical purposes it may be said that the conditions were the same for each box and for each run through the furnace.

At the conclusion of each run the boxes were allowed to cool and weights were taken of each box and its contents. The decrease in the volume of the contents was also measured. (Since the measurements of weight were more accurate than those of volume, only the former are shown in accompanying curves, Figs. 1 and 2.)

In the test from which the curves for Fig. 1 were drawn, the carburizing material was screened after the fifth and sixth runs only. In the other test the material was screened after each run. Enough new material was then added to make up for the losses due to burning and screening and the boxes were repacked and started through the furnace. This process was repeated after each run.

Discussion of Results of Shrinkage Tests

Figs. 1 and 2 show that the initial shrinkage in both tests was fairly high. The charcoal-base compound showed a higher initial shrinkage than the charcoal and coke-base material. In both cases the shrinkage decreased with succeeding runs. In the first test the com-

pound was not screened until the fifth run. This meant that the total shrinkage after this run was high. Consequently the new material required to make the compound up to the original volume was also high. This larger proportion of new material of course caused the shrinkage by burning during the sixth run to be higher than that of the fifth run. On the seventh run the shrinkage again decreased. Judging from this test alone it would seem that an addition of less than 10 per cent new material after each run should be sufficient to maintain a constant volume of this type of material. Further tests on this same material have shown that this figure is high.

The second test (see Fig. 2) using a charcoal-coke-chemical compound and screening after each run showed that after the eighth run *an addition of only 2 per cent of new material should be enough to maintain a constant volume.* (Whether this would be enough to maintain constant carburizing activity, will be discussed later.)

Correlation of Tests With Commercial Practice

The carburizing material in commercial use at the time was the same as that used in the second test. From the results of that test and other tests on activity it was considered safe to reduce the amount of new material added after each run from 33 to 20 per cent. When this was attempted it was found that 20 per cent new additions was not sufficient to maintain a constant volume. It was necessary to increase the new additions to 25 per cent. In other words while the loss in volume due to burning and screening amounted to about 2 per cent, the loss of the same compound during commercial use amounted to about 25 per cent per run through the furnace. This could only mean an excessive loss in handling.

New Handling Equipment

This led to the design and installation of a new equipment for handling the carburizing material. The design was the result of a collaboration of a conveyor manufacturer, a compound manufacturer, and the local plant engineering and metallurgical departments.

The carburizing boxes are carried to and from the furnace by a slow moving conveyor. When a box reaches the dumping station the temperature of the contents is so low that there is no danger of the compound catching fire. The boxes are dumped on a grid which retains the work and allows the compound to pass through into the handling system. All of the handling of both old and new compound

is mechanical and as gentle as possible. Proportional feeders deliver any desired ratio of old and new material into a mixer. The mixed compound is screened and spouted into boxes. The compound is never allowed to touch the floor and is never handled by hand. A definite and uniform mixture of new and old is assured. Dumping and packing stations are covered by exhaust hoods. There is sufficient time between the dumping and the packing stations for regeneration of the compound. This system has not only eliminated some of the losses in handling but has improved the working conditions. The packing room is clean and the packers work without respirators.

Since this installation has been in operation, the amount of new additions has been as low at 10 per cent and has been kept at about 12 per cent with a steady increase of the total volume of compound. It is necessary to draw out excess material occasionally and discard it. Daily test pins have shown no decrease in the quality of the carburized product. At the same time the amount of new carburizing compound used per pound of work carburized has been decreased more than 50 per cent. This should demonstrate the economic value of proper mechanical handling.

Loss of Carburizing Activity

As already stated the addition of new carburizing material is necessary in order to maintain a constant volume and a constant carburizing activity. It is entirely possible that when the losses of volume are reduced to the minimum, the loss of carburizing activity will become the predominant factor in determining the per cent of new material which must be added after each run.

Composition and Action of Carburizing Materials

Since the activity of a carburizing material under any given set of conditions depends upon its composition it may be well to discuss briefly the composition of some of the common types of solid carburizing materials before proceeding to a study of the loss of activity.

Giolitti[1] has published what is probably the most complete treatise on carburizing. He has shown that even when solid carburizing materials are used, the carburization is accomplished by means of gases produced by the carburizing material or agent. He states[2] that the

[1]F. Giolitti, translated by Richards and Rouiller, "Cementation of Iron and Steel," 1st edition, 1915. McGraw Hill Book Co.

[2]Ditto: Page 85.

depth of penetration and the concentration of carbon in the case depend upon the temperature, pressure and the quantity of gas which come into contact with a unit area of steel.

All of the solid carburizing materials contain carbon in some form. When granular carbonaceous materials are heated in closed containers, the carbon is partially burned to form either carbon monoxide or carbon dioxide. The former is a carburizing agent. Some organic materials may decompose yielding carburizing gases. It is also claimed that oil and other volatile hydrocarbons when heated will yield vapors which carburize steel. It is possible however, that a considerable portion of the vapors from the easily volatile hydrocarbons will be driven out of the carburizing box before the steel reaches the carburizing temperature. Nitrogenous materials may yield gases which will form nitrides in the surface layers of the steel. (While this is not true carburizing, the nitrides formed are very hard and the ultimate result on the properties of the steel is somewhat similar to carburizing.) Cyanides and ferrocyanides may form both carbides and nitrides.

Many of the commercial carburizing materials (both purchased and home made) contain some form of charcoal or coke or both as a base material, to which is added certain "chemical energizers" such as the carbonates of barium, calcium, and sodium. These chemical energizers when heated to the carburizing temperature decompose to some extent at least and give off carbon dioxide gas, which on coming into contact with the large excess of hot granular carbon of the base material is converted into carbon monoxide which is a carburizing gas. It must be remembered that this reaction must follow the laws of chemical equilibrium. The temperature and the pressure have an effect upon the reaction. When the carburizing compound is allowed to cool after the carburizing heat and is exposed to air, the chemicals absorb carbon dioxide from the air and are reconverted to carbonates.

The foregoing discussion has been limited to some of the more common types of solid carburizing materials. It does not cover all of the possible types. Mahin and Spencer[3] have discussed the use of ferro-alloys.

[3]E. G. Mahin and R. C. Spencer, "Depth and Character of Case Induced by Mixtures of Ferro-Alloys with Carburizing Compounds," TRANSACTIONS, American Society for Steel Treating, Vol. XV, 1929, p. 117.

Reasons for Loss of Activity

Having discussed the composition and reactions of the more common types of carburizing materials it remains to be explained why there should be a loss of activity after use. It should be obvious that if there is a loss in carburizing activity there must be some change in the chemical composition or the physical properties of the compound during use.

Changes in Chemical Composition

Changes in chemical composition may be due to the following causes:

1. *Difference in the speed of burning of different constituents.* For example charcoal burns more readily than coke. When the carburizing compound contains both of these constituents it may be found that on continued use the charcoal content will decrease and consequently the coke content will increase. This action is accentuated if the material is allowed to burn in the bins.

2. *Decomposition of a constituent which is not regenerative.* Some inorganic materials decompose at least partially when heated. Consequently their composition is not the same after the first heat. Coal and coke may give off certain volatile constituents during the first heat. It is even claimed that a simple material such as wood charcoal which is almost pure carbon changes somewhat on heating. Certainly it is known that the shrinkage is much greater during the first than during the succeeding runs. Chemicals such as cyanides decompose totally or partially during the first heat.

3. *Chemical reaction between constituents present in the carburizing container.* There may be a reaction between some of the chemical and the sulphur in the coke to form a sulphide which would be of no further value as a chemical energizer. (The writer does not know whether this action has ever been proved to exist. It is mentioned as a possibility). If there is sand or clay present in the compound there might be a reaction between such materials and certain chemicals. Some claim that there is a reaction between certain chemicals and certain metals used as carburizing containers.

4. *Mechanical loss of chemicals* It is sometimes found after a material containing chemical energizers has been in commercial use for some time that the chemical content has decreased. If the chemical is bound to the surface of the granules of the base ma-

terial, it may become loosened when the base material is partially burned or it may be mechanically rubbed off by repeated rough handling. Any scheme such as screening or fanning to remove dust and ash will also carry off loose chemical. Consequently some do not believe in frequent screening. The writer has found that the presence of loose chemical may be more injurious than a reduction of the chemical content by screening. (This will be discussed later.)

5. *Accumulation of ash.* A certain amount of ash is formed during each carburizing run. If this is not removed there will be a gradual accumulation which will in time inhibit the carburizing action.

6. *Contamination.* Carburizing materials frequently become contaminated with extraneous materials such as sand, fireclay, scale, etc.

7. *Segregation of constituents.* Another change which may take place, which is not a change in the total chemical composition, but is decidedly a change in the chemical composition in small areas, is the separation and local segregation of certain constituents in the compound. For example, the chemical energizers may become separated from the base material and may collect in pockets. Similarly segregations of ash and foreign matter may be formed. Foreign matter, ash and loose chemicals are not in themselves carburizing agents. Steel which is lying in contact with a considerable amount of such material will not be well carburized.

Change in Physical Characteristics

When a carburizing compound is used again and again the size of the individual granule gradually becomes smaller, due to burning away of the surface of the granule. If the material is not screened, there will be a gradual accumulation of ash, and possibly some loose chemicals. As a carburizing compound becomes finer on repeated use, its weight per cubic foot increases. If the material becomes very fine it may inhibit the free circulation of carburizing gases in the container. At best a carburizing compound is somewhat of a heat insulator. The finer it becomes, within certain limits at least, the more it will act as a heat insulator and the longer it will take to heat through a given size container full of compound. Also an increase of weight per cubic foot means that

the ratio of the gross weight heated to net pounds of steel carburized is greater.

Effects of Physical and Chemical Changes Upon the Carburizing Activity

Some of the physical and chemical changes just described need no further discussion. With regard to the difference in the speed of burning of the different constituents, it might simplify matters to use a single substance for the base materials. For example the base material might be all charcoal or all coke. It should go without saying that every effort should be made to minimize the separation and consequent loss of chemical energizers. Also foreign contaminations are obviously undesirable. Naturally the ideal carburizing compound would be one that did not change in physical or chemical characteristics on use. Unfortunately this seems to be impossible.

The question may well be raised whether every slight change in chemical composition and physical properties is accompanied by a corresponding change in the carburizing activity. If this were the case it would be extremely difficult to work out a schedule of new additions which would assure the same carburizing activity on every run. Fortunately the carburizing activity seems to be fairly constant over a rather wide range of composition.

About 1861 Caron is said to have proposed a mixture of 60 per cent wood charcoal and 40 per cent barium carbonate. While this is still quoted, this mixture does not seem to be commonly used. The writer does not know of a single commercially marketed compound in this country which contains 40 per cent barium carbonate. The mixtures of old and new compounds commonly used probably contain much less chemical. Consequently it does not seem advisable to demand that the chemical content in a used compound be kept up to 40 per cent.

About nine years ago the present writer[4] reported some tests which were made in order to salvage a "worn out" carburizing compound. The original mixture contained charcoal, coke, and a chemical energizer. Due to abusive use and burning in the storage bins the material had become impoverished with respect to both charcoal and chemical, while the coke content was correspondingly

[4]H. B. Knowlton, "Carburizing and Carburizing Materials", Transactions, American Society for Steel Treating, Vol. I, p. 689.

increased. Various proportions of chemically treated charcoal were added to the used material and carburizing tests were made under standard conditions. It was found that additions of chemically treated charcoal up to a certain amount produced an increase in the depth of the case and in the per cent of carbon in the various layers of the case. Further additions of chemical and charcoal, however, did not produce any greater depth of case nor concentration of carbon. In fact both the depth of case and the per cent of carbon in the various layers remained constant as nearly as could be determined. (No tests were made on mixtures containing as much as 30 per cent of chemical.)

Shepherd[5] has plotted curves showing the depth of case produced under a given set of conditions by wood charcoal and mixtures of wood charcoal with varying amounts of barium carbonate. These show that the depth of case produced by wood charcoal plus 2.5 per cent of barium carbonate is greater than that produced by wood charcoal alone. On the other hand mixtures containing greater amounts of the chemical did not produce any greater depths of case than was produced by the one containing 2.5 per cent chemical. In fact the depth of case was less when a mixture containing 40 per cent chemical was used.

These and other tests, combined with practical experience, have convinced the writer that the chemical composition of a carburizing compound may be permitted to vary between certain limits during use, but that the chemical content of the mixed material ready for packing should never be allowed to fall below a certain minimum. What this minimum figure is, may vary depending upon the type of carburizing compound and the conditions of carburizing.

Tests to Determine Limits of Composition for a Given Type of Carburizing Compound and a Given Set of Carburizing Conditions

In the experiments described in the following pages only one type of carburizing material and one set of carburizing conditions were employed. It was originally planned to use different chemicals, different base materials and carburize under different conditions, but lack of time prevented. While the figures given might not hold quantitatively, the principles of the method of testing will

[5]B. F. Shepherd, "The Influence of Barium Carbonate upon Wood Charcoal Used for Cementation", Transactions, American Society for Steel Treating, Vol. VI, p. 606.

be applicable to any type of material and any given set of carburizing conditions.

In these tests different mixtures of pre-shrunk wood charcoal and a chemical energizer composed of barium, calcium and sodium carbonates were employed. These mixtures were purely mechanical mixtures, no binder being used. The ingredients were mixed as thoroughly and uniformly as practicable. One box was packed with each mixture. Two test pins were placed in each box and every possible precaution was taken to assure that all of the conditions of carburizing would be exactly the same for each test. Only one run was made on each mixture.

While this was necessarily a laboratory test, it was attempted to duplicate the production conditions to some extent. The temperature of 1700 degrees Fahr. and the test pieces of 3115 steel were selected for this reason. The containers were necessarily smaller than those used in production but were made of the same alloy, inverted type.

After carburizing and slow cooling the test pins were sectioned and examined under the microscope. The depth of all three zones of the case was measured. The results of the two pins in each box were averaged.

The conditions surrounding these tests are as follows:

Furnace Used. Electric box type; hearth 12 by 36 inches; variable power input; automatically controlled by a recorder controller.
Charcoal Used. Wood charcoal pre-shrunk by heating to 1700 degrees Fahr. in a closed container.
Chemical Used. A physical mixture of 3 parts sodium carbonate, 3 parts calcium carbonate, and 9.75 parts barium carbonate.
Method of Mixing. Weighed amounts of charcoal and chemical mixed in a rotating barrel. No oil, molasses or other binder was used.
Containers. Two inverted-type sheet alloy boxes. Approximate dimensions: 7 9/16 inches long, 4¼ inches wide, 4 3/16 inches deep. The sides of the boxes were straight but the ends were semi-circular. Capacity: 100 cubic inches approximately. Weight of box: 4¼ pounds. Weight of cover: 1½ pounds. Type of cover: "shoe box."
Test Pins. ½ inch round by 3 inches long. S.A.E. 3115 steel, centerless ground and polished with fine emery cloth.
Operation of the Tests. Each box was packed with a different mixture of charcoal and chemical. Two test pins were placed in the center of each box. The furnace was maintained at a temperature of 1700 degrees Fahr. for a minimum of 2 hours before charging. The two loaded boxes were placed in the center of the furnace. They were not allowed to touch each other nor the sides of the furnace. The control thermocouple was placed in contact with the top of one of the boxes.

The full electric load was applied until the thermocouple reached 1700 degrees Fahr. The voltage was then reduced to 12 volts. This caused the recorder to draw a very flat curve varying about 5 degrees above and below

1700 degrees Fahr. At the end of 6 hours the current was shut off by a time clock and the boxes were allowed to cool in the furnace.

After slow cooling from carburizing the test pins were cross-sectioned polished, etched and examined under the microscope.

The above tabulation shows the details of the test and the curve (Fig. 3) shows the results. The microstructures of the cases are shown in Figs. 4 to 9.

Discussion of Results

The pins heated in the pure charcoal showed the least carburization. It will be seen in Fig. 4 that there is a layer of pure ferrite about 0.001 inch thick at the surface of one of the pins

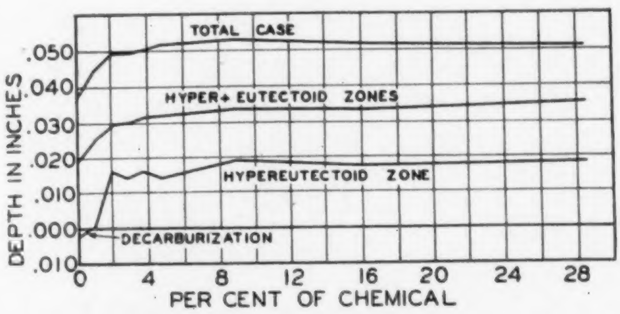
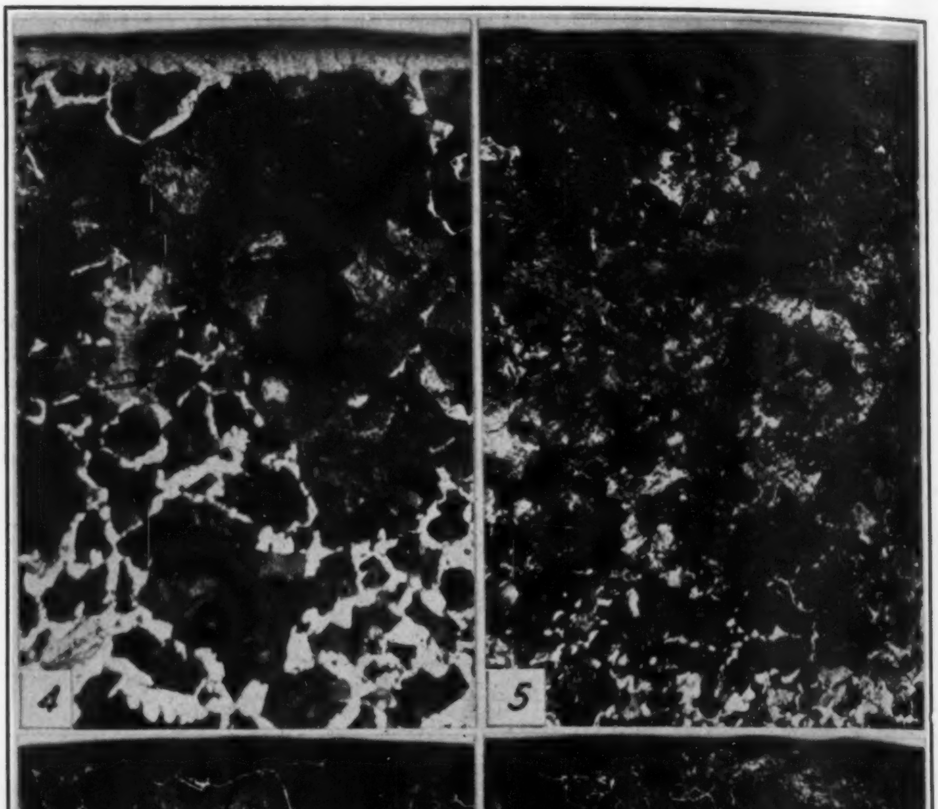


Fig. 3—Curves Showing Depth of Case vs. Composition of Compound.

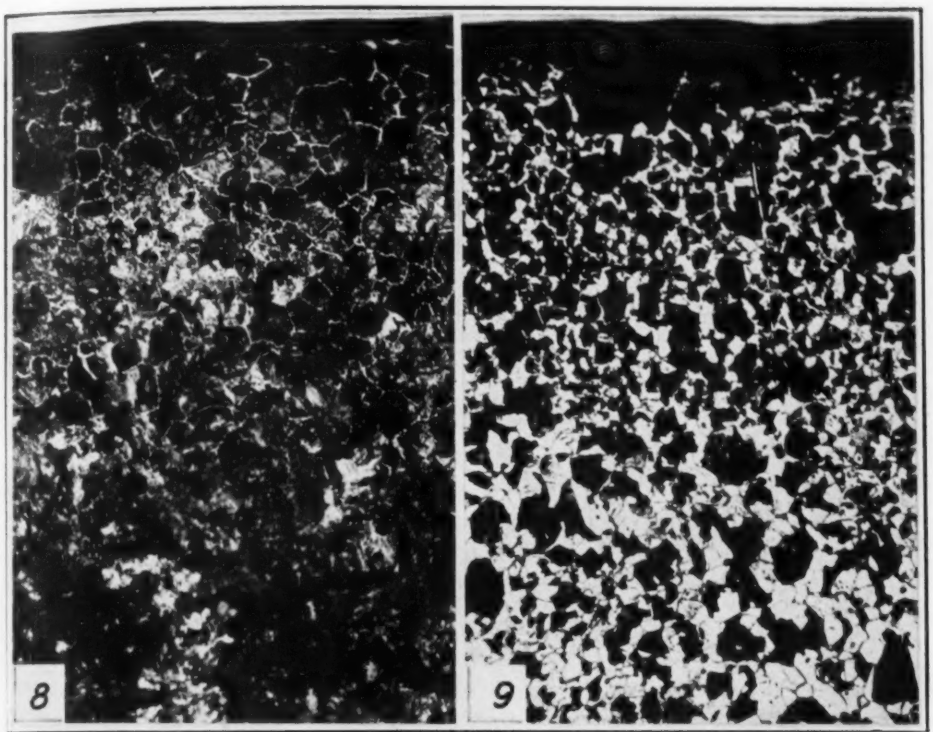
carburized in charcoal. There is some evidence of decarburization as deep as 0.007 inch below the surface. The eutectoid zone is also quite thin. Both of the pins carburized in charcoal showed the same condition.

The pins carburized in charcoal plus 1 per cent of chemical showed no decarburization but no excess cementite. The depth of case was greater than was produced by charcoal alone. See Figs. 3 and 5. All of the pins carburized in mixtures containing 2 per cent or more of chemical showed some excess cementite. Unfortunately the steel used for the test pins was not very "normal" so the cementite did not show up as sharply as might be desired.

The depth of all three zones of the case increased with increase of chemical in the compound up to about 2 to 4 per cent of chemical. From that point on the depth of case remained practically constant within experimental error of measuring for all percentages of chemical in the compound. In fact the total variation in the total depth of case produced by mixtures containing from 2 per cent to 28 per



Photomicrographs of Cases Produced by Carburizing in Different Mixtures of Charcoal and Chemical.
Fig. 4—All Wood Charcoal.
Fig. 5—Charcoal Plus 1 Per Cent of Chemical.
Fig. 6—Charcoal Plus 2 Per Cent of Chemical.
Fig. 7—Charcoal Plus 3.8 Per Cent of Chemical.
All Magnifications × 100.



Photomicrographs of Cases Produced by Carburizing in Different Mixtures of Charcoal and Chemical.
Fig. 8—Charcoal Plus 28.6 Per Cent of Chemical—Well Carburized Area.
Fig. 9—Same Test Pins as Shown in Fig. 8—Poorly Carburized Area. All Magnifications × 100.

cent chemical, was only 0.005 inch. It is difficult to locate the breaking point of the curve absolutely. If the tests were repeated several times the breaking point could be plotted more accurately.

Some of the pins carburized in mixtures containing the higher amounts of chemical showed spots of very poor carburization. An example of this is shown in Figs. 9 and 10. These show a pin which was carburized in a mixture containing 28.6 per cent chemical. Fig. 10 is a macrograph of a cross-section of the entire pin magnified about 4 times. The case is etched dark. It will be noted that there are two spots on the cross-section where there is apparently no case at all. Fig. 9 shows the microstructure of one of these areas. It will be noted that there is some evidence of carburization even in this area, although the carbon content is quite low.

The writer has attributed the presence of these poorly carburized areas to loose chemical in contact with the pin at these localities. In order to demonstrate that loose chemical might produce such

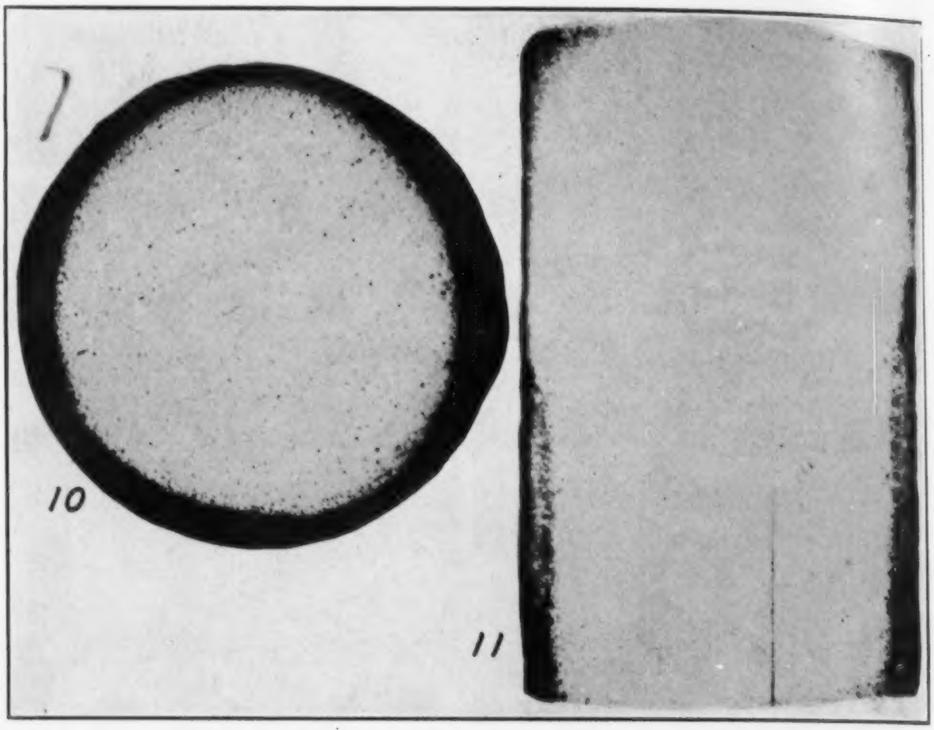


Fig. 10—Macrograph of Test Pin Shown in Figs. 8 and 9. Magnification × 4. The Carburized Portion is Etched Dark. Note the Two Spots at the Surface Showing Very Little Carburizing.

Fig. 11—Macrograph Showing Longitudinal Section Through a Pin Placed Vertically in a Box, the Lower Part of Which was Filled with Chemical and the Upper Part with Charcoal. The Portion of the Pin Which was in Contact with the Charcoal Shows Good Carburizing, While the Portion in Contact with the Chemical Shows Little or no Carburizing.

results, a carburizing box was partially filled with loose chemical. Charcoal was then placed on top of the chemical and a test pin was inserted vertically through the two layers. The box was then given the usual carburizing heat. Fig. 11 shows a macrograph of a longitudinal section of this pin at the junction of the layers of charcoal and chemical. It will be noted that there is no apparent case on that portion of the pin which was immersed in the chemical while there is a good case on the other end. This should demonstrate that loose chemical in contact with steel may be responsible for localized poorly carburized areas and, consequently, soft spots after hardening.

Conclusions from the Test

From these tests it may be concluded that for the type of carburizing material tested and the conditions of carburizing employed, the chemical content should never be allowed to fall below 2 per cent.

It might be safer to keep it always above 5 per cent. This means not only that the average chemical content of the entire supply of carburizing compound on hand should be above this figure, but also that the chemical content of the material in every box should be 5 per cent or more. It might even be said that the chemical content in every part of every box should be that high.

The chemical content of the mixed material ready for packing can be governed in part by the per cent of new material added. Thorough mixing of old and new material is necessary in order to assure that the chemical content is the same in every box. The lower the per cent of new material the more important is thorough mixing. On the other hand this test shows that loose chemical should never be allowed to accumulate in the used compound, since segregations of loose chemical are shown to produce poorly carburized areas.

Theoretical Explanation

While this paper is concerned primarily with facts rather than theories as to why certain reactions take place, it may be interesting to some to inquire why additions of chemical energizers above a certain per cent do not give a greater penetration or concentration of carbon. The writer offers the following as a possible explanation: When the chemical (carbonates) are heated they tend to give off carbon dioxide gas. This reaction, however, can probably be inhibited by gas pressure. For example if a large amount of carbonates were heated in an absolutely gas-tight container they would give off carbon dioxide gas until the pressure in the container reached a point where further evolution of carbon dioxide would be prevented, by the pressure of the gas in the container. It would not matter how much carbonate was present, only enough would be decomposed to build the gas pressure up to that point. Of course commercial carburizing containers are not gas-tight. Nevertheless there is some pressure inside these containers when at the carburizing temperature, and it is possible that an equilibrium may be built up between the pressure in that container and the decomposition of the chemical. The writer does not know whether this has ever been proven but offers this idea as a possible explanation of the behavior of compounds containing different amounts of chemical energizers.

Practical Application

In order to apply these studies to the every day carburizing

practice, the writer has instituted a periodic routine analysis of the mixed compounds at the packing stations. A complete chemical analysis of a carburizing material, however, takes some time. Consequently as a quick indication of the amount of carbonates present the writer has adopted the measurement of the carbon dioxide evolved by the addition of sulphuric acid to a weighed amount of pulverized compound. This determination can be run in a few minutes. If only one chemical is present it is a simple matter to calculate the chemical content from the per cent of CO_2. If more than one chemical is present it is necessary to know the per cent of the different chemicals in the original material and to assume that the rate of loss is the same for each of the chemicals.

The proportion of new and old compound is adjusted so that the chemical content of the mixed material is never allowed to fall lower than 5 per cent. Test pins placed in the carburizing boxes daily have shown that the carburizing has been uniform. The writer believes, however, that a chemical test on the compound before packing is safer than waiting for the examination of test pins after carburizing.

By the use of better equipment for handling, mixing, and screening the compound, and by governing the mixture of old and new material so as to assure the desired chemical composition of the mixed material, and by daily checks on the carburized product it has been possible to reduce the per cent of new material added after each from 33 per cent to about 12 per cent without in any way decreasing the quality of the work. This has meant a worth while saving in carburizing costs. The writer is not at all sure that further study may not bring even greater savings in the carburizing costs.

ACKNOWLEDGMENT

The writer wishes to thank Messrs. F. C. Smith and D. A. Webster of the International Harvester Company for their collaboration in the preparation of this paper. Mr. Smith did all the microscopic work and assisted in planning the tests while Mr. Webster did much of the actual work in carrying out the tests.

Oral Discussion

MR. BULLARD: I should like to ask the author of the paper if he cares to tell us how he determines the percentage of energizer in the compound,

and if he would care to go into the reasons why he always calls it chemical instead of stating roughly what it is.

H. B. KNOWLTON: It may be a little safer to call it chemical than refer to any particular chemical, as that might seem to be an attempt to advertise or discredit somebody's material. As it happens, the materials used in this case were all three of the common ones: barium, sodium, and calcium. The action of the chemical apparently is to decompose and give off CO_2 gas, which is converted into CO, and contact with solid carbon. There seems to be a great deal of difference in opinion. Some statements have been made that we have not been able to justify laboratory determinations on the different chemicals. We do not care to go into this. If the chemical gives off CO_2, which is converted into CO, it is producing a carburizing gas. Perhaps the temperature has some effect on that, although we have found that chemicals in a carburizing box in contact with charcoal, apparently, give off CO_2 gas at a lower temperature than some people think it does. In determining the amount of chemical in this case it was considered necessary to work out a rapid method. Analysis of carburizing material for carbonates is rather tedious. We determine the amount of CO_2 gas given off by the chemicals as an indication of the amount of chemicals present. That may not appear as being very scientific, and yet we are determining the real carburizing factor. If it is assumed that when we start with a mixture of certain amounts of 2 or 3 chemicals, that mechanical loss of one will be about as much as the others, it is possible to figure from the CO_2 content, the per cent of barium, calcium, and sodium carbonates. To run a CO_2 determination takes only a matter of a few minutes and can be made a daily routine test to make sure that the material actually in the storage bin always contains more than the required minimum amount of chemical.

M. L. FREY: I should like to know whether or not Mr. Knowlton has done any work on the proper ratio of charcoal to coke in the working pile of carburizing compound that is daily used to make up the pots. We have attacked the problem somewhat similarly with at least the same basic ideas that Mr. Knowlton had and that is one point that rapidly became of interest to us. It did not take us long to find out that the charcoal to coke ratio in the working pile of carburizing compound was not the same as in the new material that we buy. We have established some purely tentative figures from practical data. I would like to have an explanation of his experience.

H. B. KNOWLTON: Probably the simplest answer to that question is to eliminate one or the other. Either make the compound, a coke-base plus chemical, or make it a charcoal-base plus chemical, and there is no trouble. For a charcoal-coke base compound, there is a certain minimum amount of charcoal which should be present. We can give a figure that held for one particular material under a given set of conditions, which was a minimum of 25 per cent charcoal. It happened that in this material the charcoal was energized and the coke was not. Consequently, the minimum amount of charcoal also means a minimum amount of chemical. We cannot give any quantitative figures, but suggest that any maker of carburizing material is usually glad to make the material simpler for you and eliminate some of his troubles.

Educational Section

These Articles Have Been Selected Primarily For Their Educational And Informational Character As Distinguished From Reports Of Investigations And Research

THE CONSTITUTION OF STEEL AND CAST IRON
SECTION II—PART XII

By F. T. Sisco

Abstract

This installment, the twelfth of the present series, takes up the principles involved in cold working. First of all it was necessary to view the effect of cold working on the properties of steel, including its effect on the ultimate strength, hardness, elongation, torsion and bend tests. The effect of cold working upon the physical properties was found to be very much like the effect of heat treatment in that the strength and hardness increased and the ductility decreased. This discussion was followed by an explanation of plastic flow in metals and the mechanism of slip. Under this head the causes of the stoppage of slip were enumerated. This paved the way for a discussion of the hardening of metals by cold work in which it was found that the hardening was due to slip interference. The hardness and strength of cold worked steel are, therefore, due first to slip interference caused by small grains, and second to the obstruction offered by the iron carbide particles.

COLD working is one of the oldest methods known for shaping metals; probably it was discovered at the same time the metals themselves became known to man. Primarily the object of cold working is to form the metal into some definite shape. One of the greatest advantages of cold working is that it is possible to produce a section extremely accurate in size and of excellent finish, just as accurate or perhaps more so than by almost any other method

This is the twenty-second installment of this series of articles by F. T. Sisco. The several installments which have already appeared in TRANSACTIONS are as follows: June, July, August, September, November, 1926; January, February, April, June, August, October, 1927; February, April, June, November, 1928; January, March, May, June, July, September, 1929.

The author, F. T. Sisco, a director of the society, is chief of metallurgical laboratory, Air Corps, War Department, Wright Field, Dayton, Ohio.

known for working metals into a desired shape. And in addition it will do this shaping cheaply and rapidly. In general only the ductile metals such as platinum, gold, silver, copper, aluminum, iron and steel are cold worked commercially. It is a well known characteristic of this method of shaping metals that as they are cold worked the ductility decreases rapidly until finally they become so brittle that they can be worked no further without failure. But it is also true that as the ductility decreases the tenacity or strength increases. This drastic increase in strength and corresponding decrease in ductility may or may not be of commercial advantage.

In a previous installment[65] we discussed briefly the effect of cold work upon steel, and saw that in this process of shaping a steel object, severe distortion of the grains occurred. The increased tenacity or strength and the decreased ductility are the result of this distortion. We also saw that by annealing we could produce recrystallization of the grains and thus decrease the strength and increase the ductility to a point where these two properties are practically the same as they were before the material was subjected to cold working.

A piece of steel that has been severely cold worked, as wire for example, has a very high tensile strength and a very low elongation. The material is in the condition known as hard drawn. When we cold work steel severely we say that it hardens. But are we speaking correctly? In one sense we are and in one sense we are not. In ordinary terminology we think of hardness as applying to a piece of high carbon or alloy steel which has been cooled rapidly from above its critical range. The result of this very rapid cooling is a material with high tensile strength, high hardness as measured by the Brinell or scleroscope test, low elongation and great resistance to machining. This is the familiar hardness from heat treatment. If we examine such a hardened steel with the microscope we will find that the structure has a characteristic appearance known as martensite.

Now suppose we take a rod of medium or high carbon steel and cold work it severely by drawing it into fine wire. The whole operation is performed cold;[66] at no time has it been heated above its critical range and quenched. The result of this severe cold work

[65] TRANSACTIONS, American Society for Steel Treating, June 1928, page 1044.

[66] It is sometimes necessary to anneal during the drawing operation to prevent the wire breaking in the die.

is a material with high tensile strength, perhaps just as high as obtained by quenching a high carbon steel in water; and a very low elongation, just as low as that resulting from heat treatment. The hardness as measured by the Brinell test and the resistance to machining have also been increased by the severe cold work, but probably not to the degree that these two characteristics are affected by heat treatment. If we examine a section of this hard drawn wire with the microscope no martensite can be detected.

Since the hardness of a heat treated steel is due to the formation of martensite and since in cold worked steel no martensite is formed it is evident that the hardness of a quenched high carbon steel and the hardness of the same steel cold worked but not heat treated must be very different, even though some of the properties such as ultimate strength and elongation are the same. These two states of hardness resemble each other in many respects, but structurally they are as wide apart as the poles. The question that concerns us now is what structural change is responsible for the so-called hardness resulting from cold work. This hardness we will call strain-hardness. When we have discovered this structural change we should understand the difference between the hardness resulting from thermal treatment and the strain-hardness resulting from cold work.

Effect of Cold Working on the Properties of Steel

Before viewing the problem of the structural changes taking place in cold working we will pause for just a moment to consider briefly its effect on the physical properties. The first and most characteristic change in properties due to cold work is that of the ultimate strength (maximum tensile strength) or tenacity. Cold working increases the strength of steel greatly; in fact we are able to secure higher strengths by cold work than by any other method. By a combination of heat treatment and cold working we are able to obtain commercially an ultimate strength of 350,000 to 400,000 pounds per square inch.

For an average for wire we may say that cold working to the point where the material becomes hard drawn doubles or triples the ultimate strength. For example Adam [67] gives the following average properties:

[67] "Wire Drawing and the Cold Working of Steel," H. F. and G. Witherby, London. 1925, page 101.

Material	Annealed or Heat Treated	Hard Drawn
Copper	28,000 lbs./sq. in.	59,000 lbs./sq. in.
Phosphor Bronze	44,000 lbs./sq. in.	130,000 lbs./sq. in.
Nickel	60,000 lbs./sq. in.	140,000 lbs./sq. in.
Monel Metal	70,000 lbs./sq. in.	130,000 lbs./sq. in.
Ingot Iron	40,000 lbs./sq. in.	120,000 lbs./sq. in.
Low C. Steel	72,000 lbs./sq. in.	200,000 lbs./sq. in.
Medium C. Steel	105,000 lbs./sq. in.	350,000 lbs./sq. in.
High C. Steel	150,000 lbs./sq. in.	400,000 lbs./sq. in.

In general the ultimate strength resulting from cold work depends first upon the original strength of the metal and second upon the amount of reduction it has received in drafting. Higher ultimate strength is obtained in wire drawing than in any other method of cold work. While the maximum strength obtained in wire is approximately 400,000 pounds per square inch, in cold rolled strip it seldom reaches 200,000 pounds per square inch.

The following table gives some typical physical properties of cold drawn wire obtained in commercial American practice. Each result is the average of a large number of tests.

Physical Properties Cold Drawn Wire
Standard American Wire Drawing Practice

Kind of Wire	Carbon Percentage	Diameter Inches	Ultimate Strength Pounds Per Square Inch	Per Cent Elongation in 10 In.	Torsion in 6 In.
Bright Bessemer	0.10	0.3569	95,600	3.44	8-11
Bright Bessemer	0.10	0.2628	100,500	2.16	15-30
Bright Bessemer	0.10	0.1480	121,800	1.07	2-7
Bright Bessemer	0.10	0.1033	134,700	0.40	2-6
Bright Bessemer	0.10	0.0620	168,000	0.40	29-38
Coppered Soft Basic	0.10	0.1918	71,100	5.75	27-35
Coppered Soft Basic	0.10	0.0397	78,400	2.50	115-125
Coppered Soft Bessemer	0.10	0.1329	84,400	3.30	42-53
Coppered Soft Bessemer	0.10	0.0466	90,900	0.50	110-135
Coppered Bessemer	0.10	0.1904	122,600	1.40	1-8
Coppered Bessemer	0.10	0.0716	135,600	0.75	29-40
Coppered Basic	0.10	0.1875	85,100	1.75	25-35
Coppered Basic	0.10	0.0475	129,600	2.00	47-53
Fence-Hard Wire	0.10	0.1033	112,900	8.37	16-20
Premier	0.65	0.1609	189,100	2.43	11-16
Premier	0.65	0.0780	276,300	0.76	33-42
High C. Acid Steel	0.70	0.2595	150,600	2.35	4-9
High C. Acid Steel	0.70	0.1691	165,100	2.30	10-17
High C. Acid Steel	0.70	0.1155	198,900	2.22	16-22
Oil Tempered	0.80	0.0549	316,000	1.35	.....

There is very little information available concerning the effect of cold work on the Brinell hardness. This is because steel, which is cold drawn until the ultimate strength is very high, is nearly

always so small in cross section that Brinell readings are impossible. Adam performed some experiments on large size wire which indicated that the Brinell hardness generally increased proportionally with the ultimate strength, but this increase was not the same for all steel.[68] The hardness-tensile strength ratio (H/T) for hot rolled and cold drawn wrought iron was 0.0023.[69] For low carbon steel H/T is 0.0025; for medium carbon steel it is 0.0019 and for high carbon steel it is 0.0021. For heat treated carbon steels this number is fairly constant at 0.0020. In discussing his results Adam calls attention to the fact that erratic results are sometimes obtained on cold worked material, especially when the structure is heterogeneous, as for example in a wire that contains free ferrite and pearlite. In general it may be said that the increase in Brinell hardness of steels due to cold working is roughly proportional to the increase in ultimate strength, but varies considerably for each steel and for each structural condition.

Cold working decreases the elongation to a marked extent as is evidenced from the preceding table. It should be noted, however, that, although elongation is a standard test, it has very little value as a measure of ductility for cold drawn wire. As Adam says, "unless the gage length is some geometrical proportion to the diameter the elongation is of little value." In this country it is customary for the wire mills to determine elongation on a standard gage length of 10 inches, which is satisfactory for telegraph, telephone and other soft galvanized wire, but for hard drawn wire the percentage elongation obtained over this gage length is meaningless.

Two tests used frequently for determining the ductility of cold drawn wire products are the torsion test and the bend test. The torsion test not only measures the ductility of the metal but it is an excellent test to detect any local defects in the material. The number of torsions a cold drawn wire will stand is not proportional to the ultimate strength as is evident from the properties shown in the preceding table.

Bend tests are valuable in that they afford a simple check on the ductility of the material, and in addition, like the torsion test,

[68]Loc. Cit., page 97.

[69]The hardness-tensile strength ratio, H/T, is obtained by dividing the Brinell hardness number by the ultimate strength in pounds per square inch. Then the ultimate strength multiplied by this factor will give the hardness and the hardness number divided by the factor will give the ultimate strength in pounds per square inch. A similar factor may be obtained by dividing the ultimate strength by the Brinell hardness number.

will reveal defects in wire not visible on the surface and not easily detected by the tensile test. The bend test is used extensively for cold rolled strip steel, and is now included in the specifications for cold rolled streamline wire for aircraft.

There is very little information concerning the effect of cold work on the endurance limit of steel. On such tests as have been made the results indicate that the endurance limit is independent of the proportional limit and the yield point, and holds about the same relation to the ultimate strength as it does in heat treated carbon and alloy steels.

It is evident from this brief review of the physical properties that cold work produces a change in the characteristics of steel that is similar in many respects to the effect of thermal treatment. Cold work and heat treatment (hardening) both increase the tensile strength, hardness and endurance limit. They both decrease the ductility as measured by the elongation. But with these characteristics the similarity ceases. A properly treated wire can be hard drawn to 300,000 pounds per square inch and still be sufficiently ductile so that it can be wrapped around its own diameter. A high carbon steel heat treated to the same tensile strength would not be so ductile. It is plain that there is a great difference in the hardness resulting from heat treatment and that resulting from cold work.

Now having viewed the effect of cold work on the properties of steel we will pass on to a consideration of the structural changes taking place in this process. The first thing which will interest us is the mechanism of plastic deformation.

Plastic Deformation in Metals

Deformation of a substance is change in its external form. Solid substances under stress undergo a deformation of either of two kinds, fluid deformation or plastic deformation. If the wooden staves are removed from a barrel of pitch or tar the contents will, over a period of hours or days, gradually settle down into a large pancake-like mass. The pitch may be so hard and brittle that it is possible to chip pieces off of the cake with a hammer, but, nevertheless, it will gradually settle downward. This sluggish deformation of such amorphous solids as pitch, glass and the like is known as fluid deformation; solid materials such as these are only fluids of high viscosity.

If a piece of copper or iron is put into a tensile machine and

stretched it will elongate as much as 25 per cent or more without rupture. This stretching, characteristic of many crystalline metals, is known as plastic deformation and consists of the crystal particles or groups of atoms sliding over each other on planes of weakness known as slip planes. The property of many crystalline metals of undergoing permanent deformation without failure is known as plasticity. Plasticity is a factor in the ductility of a substance. Jeffries and Archer define ductility as the property by virtue of which a substance may be drawn out in tension without rupture. It involves a combination of plasticity and tensile strength, and is generally measured by the percentage of elongation and reduction in area of the tensile test piece.

Let us view this phenomenon of plastic deformation a little more closely. If a pure metal such as iron is polished, etched and examined by the microscope the structure will consist of polyhedral grains of ferrite. A specimen of Armco iron so prepared is shown in Fig. 86. Now if the piece is subjected to a load which results in a slight permanent deformation a series of parallel lines will appear within the individual grains. Fig. 87 shows the lines which have appeared within a single grain of Armco iron after stressing in compression beyond the yield point. It will be noted in Fig. 87 that in general these lines are approximately straight and parallel. When a specimen such as shown in Fig. 86 is deformed but slightly just a few lines are seen; further deformation apparently increases their number. As the piece is stressed still more a new set of lines appears, crossing the first set. (Fig. 88.) These lines within the grains which are caused by stress have been carefully studied by many investigators and have been found to be visible evidence of slip of the particles along crystallographic planes. The lines observable under the microscope are actually steps on the polished surface caused by the raising or lowering of a portion of a grain. If the specimen is now repolished the slip bands disappear. Jeffries and Archer state that a slip band becomes visible under the microscope only after a relatively severe deformation, when the particle has moved approximately 0.00001 inch or about 1,000 atom diameters.

If a ductile metal such as iron or steel is subjected to a deforming load at or near atmospheric temperature, for example in cold rolling or cold drawing, the grains are stretched out in the direction of working. This elongation due to cold deformation is, as

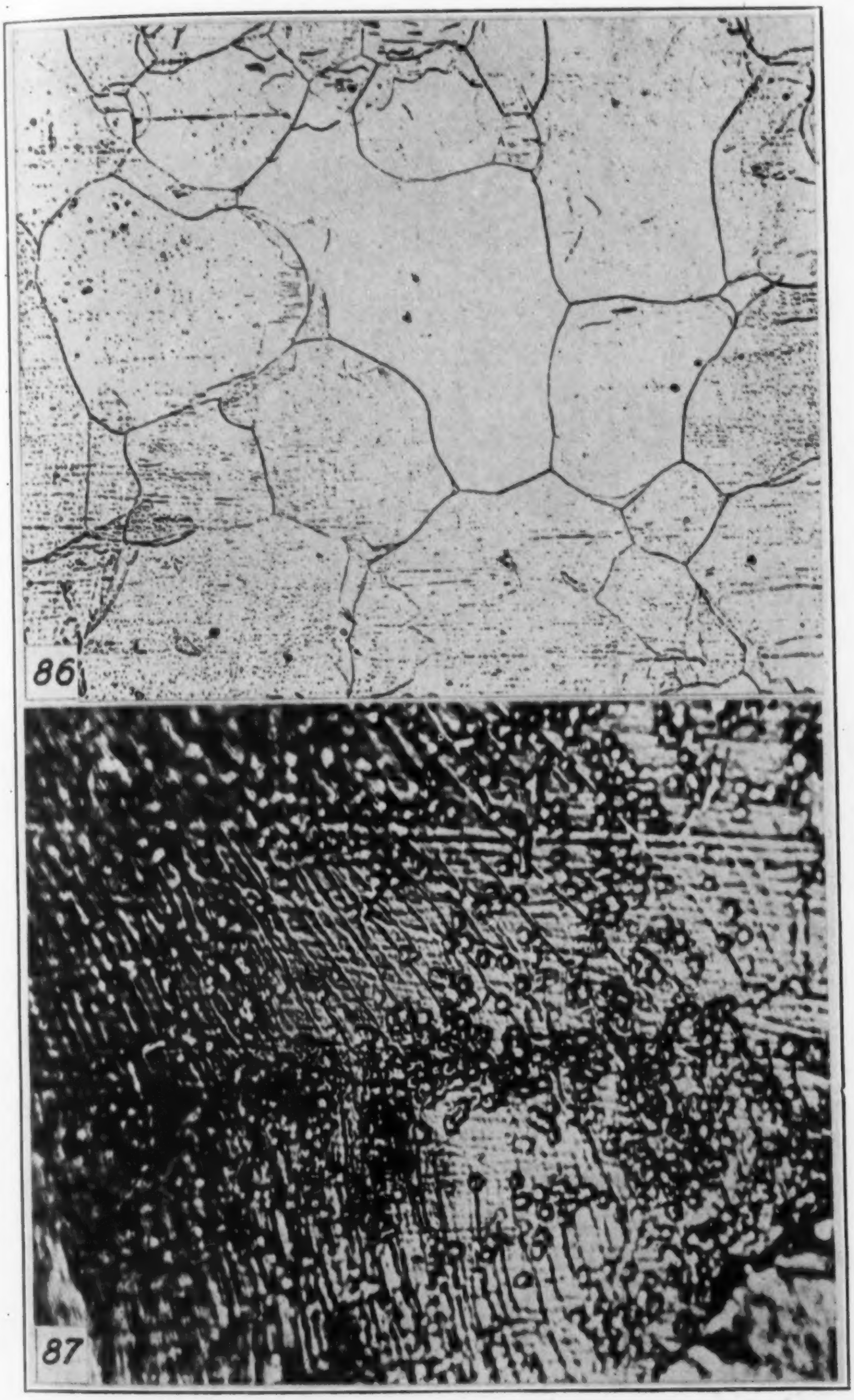


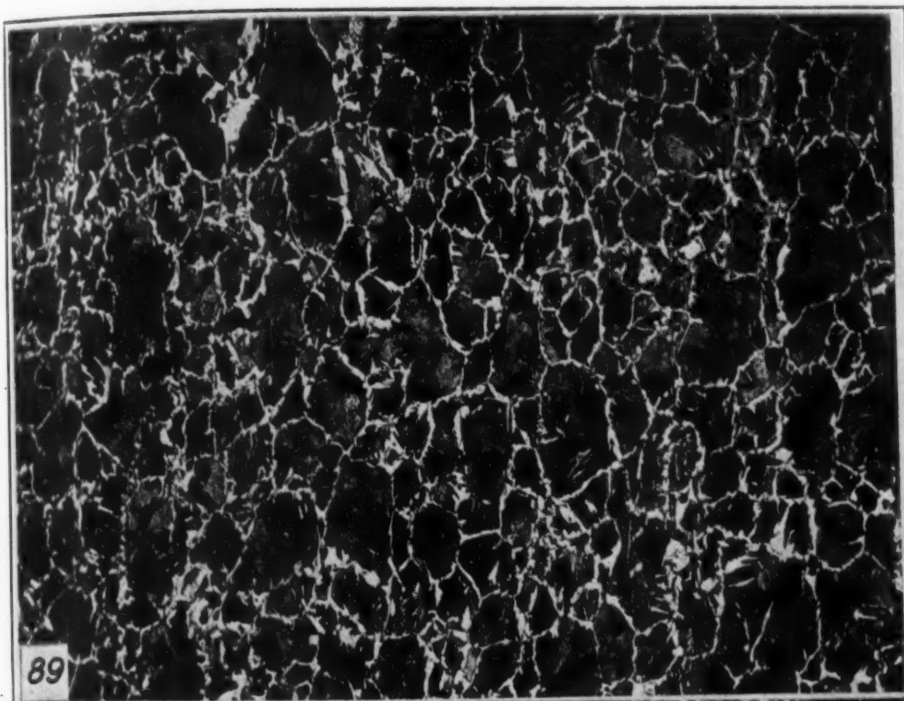
Fig. 86—Polyhedral Grains in Armco Iron. × 100. Etched in Alcoholic Nitric Acid.

Fig. 87—Armco Iron, Polished and Etched and then Stressed Beyond the Yield Point. Slip Lines Within a Single Grain. × 500. Etched in Alcoholic Nitric Acid.

Fig. 88—Same as Fig. 87 but Stressed Still More and for a Longer Time. Slip Lines Crossing Each Other. × 800. Etched in Alcoholic Nitric Acid.

we have seen, due to a series of slips along the crystal planes. This plastic flow occurs within the crystal. This is shown clearly in Fig. 89 and Fig. 90. Fig. 89 is the structure of the threaded section of an aircraft streamline wire and Fig. 90 is the streamline portion of the same wire. Both specimens were cut longitudinally to the major axis of the wire. The grains of the threaded section are approximately equiaxed, but in the streamline section they are much elongated.

What has happened in order to produce two such different structures in the same piece of steel? The grains are subjected to a high stress in the streamline portion and gradually elongate more and more until what was originally the equiaxed normal grain structure shown in Fig. 89 becomes the elongated fibrous grain of Fig. 90. The load applied has been sufficient to cause slip along the planes of weakness within the individual grains. Failure occurs along these crystallographic planes, but the fragments do not lose their coherence completely, hence deformation takes place without actual rupture. In other words, under stress a collection of atoms slides along these crystallographic planes, but does not slide far



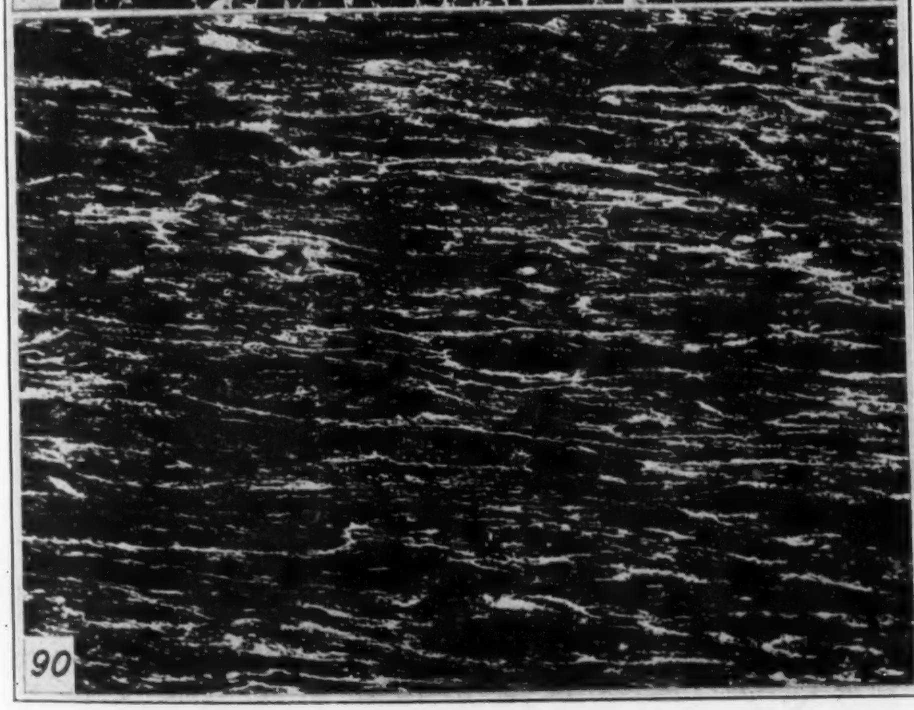


Fig. 89—Equiaxed Grains in Medium Carbon Steel, not Cold Worked. × 100. Etched in Alcoholic Nitric Acid.

Fig. 90—Same Specimen as Fig. 89, Cold-Worked, Showing Elongated Grains. × 100. Etched in Alcoholic Nitric Acid.

enough so that the bonds holding it to another collection of atoms are broken permanently.

But when slip once starts why does it stop; why does it not continue until the atomic bonds are broken completely? Jeffries and Archer say[70] that there are two reasons why slip stops. The first is that as slip proceeds the plane builds up a resistance greater than the resistance to the beginning of slip on some new plane. The slip is thus said to be self-stopping. If a ductile metal is stressed in tension, for example, slip starts on a plane of weakness and continues until it is stopped by the resistance of the plane itself. If the stress is maintained slip starts on another plane and continues until it is stopped by the resistance of this slip plane and so on. The second cause of the stoppage of slip is the end-resistance of the slip plane. The evidence in favor of this idea lies in the fact that failure does not occur by slip along one plane because large single crystals of ductile metals draw out in tension in the form of wedges.

According to Beilby's classic theory, when a ductile metal is deformed by cold work, the crystal fragments slide along each other on these crystalline planes of weakness, and in so doing generate a layer of hard amorphous metal on the slip plane which acts as a cement and prevents further slip. In Beilby's experiments he produced a layer of amorphous metal on the surface of metals by polishing them. Beilby's original hypothesis of the formation of this hard amorphous cement is now generally held as untenable.[71] As Jeffries and Archer pertinently say: "Tungsten wire drawn to 200,000 times its original length without intermediate annealing still gives strong X-ray patterns showing that it is predominantly crystalline.

Hardening of Steel by Cold Work

If we cool slowly a steel containing 0.85 per cent carbon from above the critical range it tends to assume a state of stable equilibrium with the result that at atmospheric temperature the structure consists wholly of pearlite. If we heat this steel again no structural change will take place until the lower critical point is reached, $Ac_{3\cdot2\cdot1}$, but on passing through this point the structure changes

[70]Jeffries and Archer, The Science of Metals, 1924, page 81.

[71]Loc. Cit., page 80.

from pearlite, the aggregate of ferrite and cementite stable below the range, to austenite, a solid solution of iron carbide in gamma iron stable above the range. Now if we cool this high carbon steel very rapidly the normal change to pearlite is prevented and we have at atmospheric temperature a structure known as martensite. The physical properties are changed radically, the tensile strength has increased from approximately 100,000 pounds per square inch to possibly 300,000 pounds per square inch, and the hardness has increased from about 180 Brinell to 600 Brinell or more. The elongation has decreased from 10 per cent to almost zero.

If we take this high carbon steel containing 0.85 per cent carbon in its stable structural condition of pearlite (or preferably sorbite) and cold work it by drawing through dies we can also increase the tensile strength to approximately 300,000 pounds per square inch and decrease the elongation to practically zero without heating through the critical range and quenching. We have hardened the steel by cold work, and without producing the structure of martensite. The thing which concerns us now is what causes this marked hardening effect without the accompanying structural changes induced by heat treatment. Cold deformation distorts the grain in the direction of work. It is evident that something has happened during this distortion that is responsible for the hardening which results.

One of the first explanations advanced to make clear this hardening is the amorphous cement hypothesis, as was mentioned early in this series. Rosenhain and Ewen advanced the opinion years ago that when a metal or alloy crystallizes from its melt amorphous metal is formed at the grain boundaries where the space was insufficient for the solidifying material to assume the crystal orientation of the adjacent grains. This amorphous metal was hard and vitreous and acted as a cement between the grains. This hypothesis explains why the fracture in a crystalline metal passes through the grains instead of following the grain boundaries. Beilby's hypothesis assumes that this amorphous metal also forms on the slip plane during cold deformation and thus acts as a cement preventing further slip. According to these older hypotheses the hardening from cold work is due principally to the formation of this amorphous metal at the grain boundaries and on the slip planes. But we have just quoted Jeffries and Archer a few moments ago to show that metals cold drawn severely, to the point where they

should be almost completely amorphous are still predominately crystalline.

These two authorities sum up their discussion of the amorphous metal hypothesis[72] by stating that there is evidence to justify the assumption that the grain boundary material possesses characteristics of typical vitreous amorphous metals and plastic deformation below the temperature of recrystallization results in the formation of additional amorphous metal at the boundaries of the original grains. But, they say, the formation of vitreous amorphous metal at all internal surfaces of slip in the manner postulated by Beilby is not tenable and the hardness produced by cold work can be readily explained without the assumption of such amorphization. They conclude by saying that the conception of amorphous metal at the grain boundaries furnishes a good explanation of the strength properties of certain metals and is a very good working hypothesis but the importance attached to the specific hardness of amorphous metal as a cause of hardening has been greatly exaggerated.

We may conclude from this that amorphous metal is responsible for some of the hardness and strength evidenced by cold worked metals but is a very minor factor.

If amorphous metal is not responsible for all of the hardness due to cold work the cause must necessarily be found in the slip planes. There is no doubt but that the strength of the plane increases as slip continues until it halts on this plane. Then too, if a metal is cold worked some of the grains are greatly distorted, even ruptured, resulting in the formation of new and smaller grains with somewhat different orientation. This has been proved by X-ray analysis. Slip is thus halted by the interference of adjacent grains.

Thus it becomes evident that the hardening due to cold work is due to slip interference which depends upon several factors. Cold work produces a structure made up of many fine grains; each fragment probably having a slightly different orientation. Slip is thus stopped by the boundaries of these fragments. This is given by Jeffries and Archer as the principal cause of strain hardening. The other factors are the resistance to slip of the slip plane itself, and the additional amorphous metal generated by cold work at the grain boundaries.

There have been other theories advanced to account for the

[72]Loc. Cit., page 83.

hardness due to cold work. One of these is essentially as follows: When slip occurs amorphous metal is not necessarily formed, but instead there is a grinding effect which produces a sort of crystalline debris on the plane thus halting further slip. Another theory accounts for strain hardening by the production of internal elastic stresses.

We may sum up briefly the causes of strain hardening by saying that it is due to slip interference with the following factors tending to stop the slip: (1) cold work produces many very small grains with an increased number of grain boundaries where slip may be halted. (2) Hard amorphous metal is present at these grain boundaries and there is possibility of additional amorphous metal being generated. (3) As slip proceeds on any one plane the resistance of the plane is increased until slip halts. This is essentially the present theory of the hardening of ductile metals by cold work.

Now, how about steel? The hardening of steel by cold work is due to slip interference with the above three factors entering. But there is also an additional factor that enters when carbon is present, and a very important factor too. This is the obstructing effect of the carbide particles. Pearlite is harder than ferrite due to the increased resistance to slip in the ferrite grains because of the hard compound iron carbide; and reasoning along the same line, sorbite is harder than pearlite because of the smaller grain size of the ferrite and the increased dispersion of the smaller cementite particles.

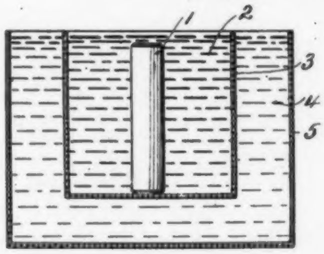
Pure iron (ferrite) is harder and stronger when cold drawn than when annealed because of the production of many small ferrite grains and because of the additional amorphous metal formed at the grain boundaries. A cold drawn 0.80 per cent carbon steel is harder and stronger than when annealed because of the presence of many small grains and possibly because of the additional amorphous metal formed at the grain boundaries; and this high carbon steel is harder and stronger when cold drawn than pure iron or low carbon steel—provided of course that they have all received the same amount of cold work—because of the obstruction offered to slip by the many small carbide particles present.

Reviews of Recent Patents

By NELSON LITTELL, Patent Attorney
475 Fifth Ave., New York City—Member of A. S. S. T.

1,719,564, July 2, 1929, Magnetizable Element and Process of Treating Same, Charles H. Seymour, of Kansas City, Missouri.

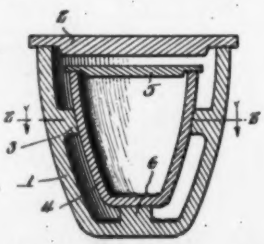
This patent describes a method of heat treating a magnetizable element, such as a soft iron core 1, or a transformer, which is heated to a very red heat and then immersed in an oleoresinous material, such as



turpentine 2, held in any suitable container 3 which is water cooled by the bath 4 in an outer container 5. Heat treatment in this way reduces the heating effect of the magnetizable element when in service.

1,720,327, July 9, 1929, Crucible, Gaylord H. Halvorson, of Duluth, Minnesota.

This patent describes a double wall crucible having an outer wall 1, a removable cover 2 and lugs or bosses 3 and 6 which serve to locate an

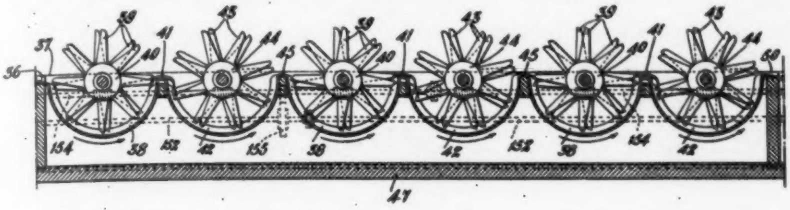


inner crucible 4 spaced from the walls of the outer crucible 1. This crucible is intended for general purposes and particularly for determining the volatile content of fuel, such as coal.

1,720,525, July 9, 1929, Apparatus for Treating Pipes, Bars, Etc., Kurt Theodore Potthoff, of Brooklyn, New York, Assignor to U. S. Galvanizing & Plating Equipment Corporation, a corporation of New York.

This patent describes an apparatus for the pickling and washing of pipes or other tubular articles comprising a tank 47 having a plurality of

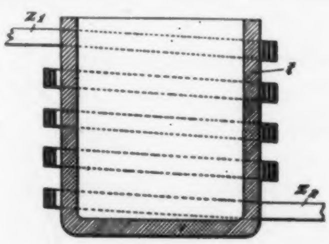
cradles 38 in which spider arms 39-43, etc., rotate. The pipe to be pickled or washed is inserted at the point 36 and is conveyed by the arms 39 through the first cradle 38, then conveyed to where it rolls off onto the support 41 and goes into the second cradle, etc. The spiders of the arms 39 and 43 are misaligned so that the pipe is alternately tipped from right



to left so that the cleaning solution, which has entered into the interior of the pipe, will flow out first from one end and then from the other. The arms of the spiders 39 and 43 are driven by the shaft 154 and suitable worm connections.

1,721,073, July 16, 1929, High-Frequency Induction Furnace, Wilhelm Esmarch, of Berlin-Halensee, Germany, Assignor to Siemens & Halske, Aktiengesellschaft, of Siemensstadt, Near Berlin, Germany, a corporation of Germany.

This patent describes a new winding for high frequency induction furnaces which is designed to reduce the skin effect between the windings. Instead of water cooled tubes, the crucible t is helically wound with three



or four layers of thin copper strips Z-1, Z-2. The thickness of the copper strips is selected to provide a minimum skin effect at the frequency used and the current is therefore more completely utilized. Various modifications are described in the patent.

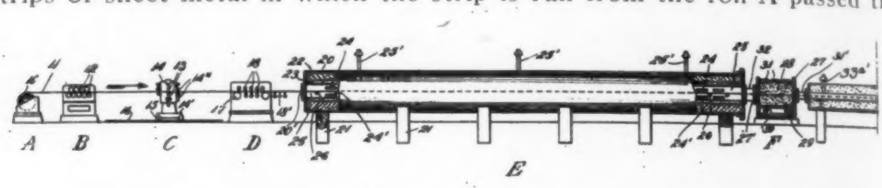
1,719,649, July 2, 1929, Pickling and Cleaning of Metal, 1,719,650, July 2, 1929, Pickling of Metals, 1,719,167, July 2, 1929, Cleaning of Metals, Etc., 1,719,168, July 2, 1929, Pickling of Metals, Etc., George D. Chamberlain, of Ashland, Kentucky, Assignor to R. T. Vanderbilt Company, Incorporated, of New York, N. Y., a corporation of New York.

These patents relate to the pickling of metals and describe various improvements in pickling solutions of nonoxidizing mineral acids in which the formation of hydrogen is reduced and other improvements effected by using various additions to the bath, such as a condensation product of

aldol with alpha napththylamine, dibenzylaniline together with thiocarbanilid, a condensation product of acetone with ammonia, and hexamethylenetetramine.

1,721,350, July 16, 1929, Continuous Annealing Apparatus, 1,721,351, July 16, 1929, Continuous Annealing and Cleaning Process, Harry M. Naugle and Arthur J. Townsend, of Canton, Ohio, Assignors, By Mesne Assignments, to The American Rolling Mill Company, of Middletown, Ohio, a corporation of Ohio.

These patents describe apparatus for the continuous annealing of strips of sheet metal in which the strip is run from the roll A passed the



leveler B and a traveling spot welder C to the washer D and electric heating furnace E, asbestos seal F and then through deoxidizing and cooling ducts to a point where it is rewound on a roll. The two patents describe the details of construction of the various stations used and of the method of operation.

1,723,319, Heating-Furnace Apparatus. Ernst Wirz, Baden, Switzerland, assignor to A. G. Brown, Boveri & Cie, Baden, Switzerland.

In this furnace, a protective heat-radiating casing is provided over the heating elements. Articles to be heated are supported in proximity to the heat-radiating walls of the casing.

1,723,538, Heating Apparatus. Joseph E. Batie, Detroit, Mich., assignor to Kelsey Wheel Company, Inc., Detroit, Mich.

This heating apparatus comprises a vertically extending heating chamber for receiving the articles to be heated and spacers between the articles, the chamber having a discharge opening in the upper portion of its wall. The articles are elevated into the chamber through its lower end and the articles and spacers are automatically separated when removed from the chamber through the discharge opening.

1,718,732, June 25, 1929, Method of Furnace Operation. George L. Danforth, Jr., Chicago, Ill., assignor, by mesne assignments, to Open Hearth Combustion Co., Chicago.

1,718,779, June 25, 1929, Heat-Drawing Furnace. Ernest F. Davis, Muncie, Ind., assignor to Warner Gear Company, Muncie, Ind.

1,718,798, June 25, 1929, Furnace. Clifford Nelson, Sheffield, England.

THE ENGINEERING INDEX

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In the preparation of the Engineering Index by the staff of the American Society of Mechanical Engineers some 1700 domestic and foreign technical publications received by the Engineering Societies Library (New York) are regularly searched for articles giving the results of the world's most recent engineering and scientific research, thought, and experience. From this wealth of material the A. S. S. T. is supplied with this selective index to those articles which deal particularly with steel treating and related subjects.

AIRPLANE MANUFACTURE

HEAT TREATMENT. Metals Applied to Airplane Construction, H. Crary. *Heat Treating and Forging*, vol. 15, no. 6, June 1929, pp. 709-711, 5 figs.

Description of heat treatment which transforms steel and aluminum alloys in manufacture of airplane parts; "maximum strength with minimum weight" is byword of makers; methods employed in Boeing Airplane Co., Seattle; electric furnaces controlled thermostatically; have ovens 3.5 and 10 ft., respectively, in interior length.

HEAT TREATMENT. Metallurgy Discloses Value of Alloys in Airplane Manufacture, C. B. Phillips. *Iron Trade Rev.*, vol. 85, no. 6, Aug. 8, 1929, pp. 325-327, 4 figs.

Methods employed by Fairchild Airplane Manufacturing Corp. for producing planes and engines; more than 10 different alloy steels used; heat treating facilities use of lighter weight alloys for fuselage construction by imparting greater strength; operations and metals used are outlined.

AIRPLANE MATERIALS

METALS. Failures in Aircraft Engines. *Metallurgist* (*Supp. to Engineer, Lond.*), July 26, 1929, pp. 97-98.

Need for closer control in selection, manufacture and testing materials for airplanes; source of dangers in British Engineering Standards Association aircraft specifications; precautions suggested cover systematic use of factor of safety applied on basis of time of service, or endurance and research in response of materials to service conditions of stress, temperature, corrosion and to variations in manufacturing conditions.

NONFERROUS METALS. Metals are Indispensable in the Air, J. F. Hardecker. *Metal Industry* (*N. Y.*), vol. 27, no. 7, July 1929, pp. 315-318, 3 figs.

Use of heavy nonferrous metals and alloys in modern aircraft is discussed; applications of copper, true and complex brasses and bronzes, Monel metal, babbitt, and other heavy metals are described.

ALLOY STEEL

Heat-Resisting Steels (Warmfeste Staehle), E. Houdremont and V. Ehmcke. *Archiv fuer das Eisenhuettenwesen* (*Duesseldorf*), vol. 3, no. 1, July 1929, pp. 49-59 and (discussion) 59-60, 16 figs.

Test method for determination of behavior of steel at high temperature is described; classification of heat-resisting steels according to degree of working temperature; influence of alloying and heat treatment on heat-resisting properties of steels in temperature range below 650 deg.; factors governing production of heat-resisting steels for temperatures from 650 to 1000 deg. Cent.; melting point and recrystallization temperature.

ALLOYS

Metals and Alloys for Industrial Applications Requiring Extreme Stability, J. Strauss. *Am. Soc. for Steel Treating*—TRANS., vol. 16, no. 2, Aug. 1929, pp. 191-226, 2 figs.

Paper records uses of most widely applied metals and alloys, under conditions demanding permanence, either superficial, or otherwise, usually when exposed to active destructive agents, in some form as corrosion, erosion and elevated temperature; these three agencies are first discussed in detail; various alloys are described, grouped accordingly to element present in their composition in major proportion. Bibliography. Read before West. Metal Congress.

ALUMINUM

PROTECTIVE COATINGS. Protection of Aluminum by Depositions Made in Saline Solutions (Protection de l'aluminium par dépots effectués dans des solutions salines). *Revue de Métallurgie* (*Paris*), vol. 26, no. 6, June 1929, pp. 309-310.

Results of experiments show that saline protection is practically valueless.

ALUMINUM ANALYSIS

Use of 8-Hydroxyquinoline in Separations of Aluminum, G. E. F. Lundell and H. B. Knowles. *U. S. Bur. Standards—Jl. of Re-*

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search, vol. 3, no. 1, July 1929, pp. 91-96.

Data presented show that precipitations with 8-hydroxyquinoline serve to separate aluminum from phosphorus, arsenic, fluorine, and boron if made in ammoniacal solutions, from tantalum, columbium, titanium, and molybdenum if made in ammoniacal solutions containing hydrogen peroxide, and from uranium if made in ammonium-carbonate solutions; others have shown that aluminum can also be separated from beryllium if precipitation is made in acetic acid solution.

ALUMINUM BRONZE

Aluminum Bronze Data. *Foundry*, vol. 57, no. 14, July 15, 1929, foundry data sheets no 773 and 774.

Precautions to counteract trouble due to drossy patches originating in melt; elimination of pinholes; melting and pouring temperatures; sand condition. (Continuation of serial.)

ALUMINUM CASTINGS

Advantages of Aluminum as a Foundry Material, G. Mortimer. *Can. Foundryman (Toronto)*, vol. 20, nos. 6 and 7, June and July 1929, pp. 28-30 and 14-16, 3 figs.

June: Discussion of four characteristics of aluminum; precautions in handling cores; shrinkage allowances. July: Importance of careful venting and light ramming; proper length of runners and risers to obtain equivalent pressure in mold; finishing, repairing, and fusion welding are discussed. (Continuation of serial.)

ALUMINUM CORROSION

Corrosion Phenomena on Aluminum Sheets (Korrosionserscheinungen an Aluminiumblechen), R. Wesenberg. *Chemische Fabrik (Berlin)*, no. 18, May 1, 1929, p. 208, 1 fig.

Pinhole corrosion of rolled aluminum sheets may be due to inclusions of suboxide of aluminum.

ALUMINUM SPECIFICATIONS

99 Per Cent Aluminum Notched Bars and Ingots. *British Eng. Standards Assn. (Lond.)*, no. 360, June 1929, 6 pp.

Specifications cover quality of material, manufacture, provision of samples for analysis.

89 Per Cent Aluminum Bars and Ingots for Re-Melting Purposes, Rolling Slabs and Billets. *British Eng. Standards Assn. (Lond.)*, vol. 359, June 1929, 9 pp.

Specifications cover quality of material, manufacture, provision of samples for analysis.

ALUMINUM TESTING

Influence of Dimension of Test Pieces in Viscosity Tests of Metallurgical Products (Influence de la dimension des éprouvettes dans les essais de viscosité des produits métallurgiques), J. Cournot. *Academie des Sciences—Comptes Rendus (Paris)*, vol. 188, no. 15, Apr. 8, 1929, pp. 995-997.

Experiments at 15 to 200 and 200 to 350 deg. on aluminium (99.9 per cent), and commercial duralumin wire, respectively, annealed at 350 deg. showed that practical limit of viscosity increases with diameter (1-2.8 mm.) at rate which is rapid for fine wires but appears to approach asymptotic value for thicker wires; in latter case temperature has only slight influence on rate of increase.

ALUMINUM ALLOY CASTINGS

SPECIFICATIONS. 12 Per Cent Copper Aluminum Alloy Castings for General Engineering Purposes. *Brit. Eng. Standards Assn. (Lond.)*, no. 362, June 1929, 7 pp., 1 fig.

Specifications cover, quality of material, chemical composition, chemical and mechanical tests, provision of test samples, marking accepted and rejected material, inspection.

SPECIFICATIONS. Zinc-Copper Aluminum Alloy Castings. *British Eng. Standards Assn. (Lond.)*, no. 363, June 1929, 7 pp., 1 fig.

Specifications cover quality of material, chemical composition, chemical and mechanical tests, provision of test samples, marking accepted and rejected material, inspection.

SPECIFICATIONS. 7 Per Cent Aluminum Alloy Castings for General Engineering Purposes. *British Eng. Standards Assn. (Lond.)*, no. 361, June 1929, 7 pp., 1 fig.

Specifications cover quality of material, chemical composition, chemical and mechanical tests, provision of test samples, marking accepted and rejected material, inspection.

ALUMINUM ALLOYS

AGE HARDENING. The Age Hardening of Aluminum Alloys, Fraenkel and L. Marx. *Metallurgist (Supp. to Engineer, Lond.)*, June 28, 1929, pp. 93-94, 3 figs.

Researches were carried out on hardness, strength, and electric conductivity of five alloys aged at room temperature and at higher temperatures, and also aged after so-called "Kochverguetung" treatment; in this latter method alloys are quenched from high temperature, not in cold water but hot water, and are kept there for short time and aged still further at room temperature. Abstract translated from *Zeit. fuer Metallkunde*, Jan. 1929, previously indexed.

AGE HARDENING. The Stability of Aluminum and Magnesium Casting Alloys, A. J. Lyon. *Machy. (Lond.)*, vol. 34, no. 871, June 20, 1929, p. 368.

Aging properties and age hardening of aluminum and magnesium casting alloys discussed; that most important changes involved in process in some aluminum and magnesium-base alloys do not take place at atmospheric temperature in comparatively short time after casting or heat treatment is shown; investigations carried out by U. S. Air Corps discussed. From Technical Publication No. 133 of Am. Inst. Min. and Met. Engrs.

ANALYSIS. Preparation of Aluminum Alloys for Microscopic Analysis (Herrichtung von Aluminiumlegierungen fuer die mikroskopische Untersuchung), H. Choulant. *Zeit. fuer Metllkunde (Berlin)*, vol. 21, no. 6, June 1929, pp. 197-199, 8 figs.

Etching media and methods employed for etching of aluminum alloys such as duralumin were investigated, based on which method was developed which is described

and recommended; its application to cast alloys and to quenched and annealed duralumin is demonstrated.

ANALYSIS. Analysis of Aluminum Alloys, H. Gibb. *Indus. Chemist (Lond.)*, vol. 54, no. 50, July 1929, pp. 286-288 and 291.

Methods for analysis of more common metals which are found alloyed to aluminium in foundry where expense electrolytic apparatus is not available; aim has been to adapt various standard methods used for estimation of metals in aluminium alloys.

CEMENTATION. Cementation of Light and Very Light Alloys as Protection Against Sea-Water Corrosion (Cémentation des alliages légers et ultra-légers en vue de luer protection contre la corrosion a l'eau de mer), J. Cournot and E. Perot. *Revue de Métallurgie (Paris)*, vol. 26, no. 6, June 1929, pp. 318-325, 9 figs.

Cementation of aluminum with copper is discussed.

ELECTROPLATING. Protection of Metals, Light Alloys and Very Light Alloys Against Sea-Water Corrosion by Electrolytic Deposition (Recherches sur la protection des métaux et alliages légers et ultra-légers contre la corrosion a l'eau de mer par recouvrements électrolytiques), J. Cournot and J. Bary. *Revue de Métallurgie (Paris)*, vol. 26, no. 6, June 1929, pp. 312-318.

Notes on copper plating, cobalt depositions, cadmium plating, nickel and chromium plating; results of corrosion tests in artificial sea water.

PROTECTIVE COATINGS. Study of Protection of Light Alloys by Varnish with Coal-Tar Base (Etude de la protection des alliages légers par les goudrons), Aubert and A. Pignot. *Revue de Métallurgie (Paris)*, vol. 26, no. 6, June 1929, pp. 310-312.

Possible use of coumarone (Benzofuran) and by-products of gas plants as protective coatings.

PROTECTIVE COATINGS. Method for Rapid Analysis of Permeability and Adhesiveness of Varnishes Used in Protection of Light Alloys (Méthode permettant une appréciation rapide de la perméabilité et de l'adhérence des vernis employés à la protection des alliages légers), M. Aubert and G. Dixmier. *Revue de Métallurgie (Paris)*, vol. 26, no. 6, June 1929, pp. 307-308.

Method described is claimed to be much more rapid than usual method employed.

BEAMS, STEEL—TESTING

Tests of Fixed and Simply Supported I-Beams Made of Steel St. 37 (Versuche mit eingespannten und einfachen Balken von I-Form aus St 37), Maier-Leibnitz. *Bautechnik (Berlin)*, vol. 7, no. 20, May 10, 1929, pp. 313-318, 27 figs.

Results of further tests, made at Stuttgart Institute of Technology, of beams 1.6 m. long, or longer.

BEARING MATERIALS

Bearing Metals (Betrachtung einiger Werkstoffe fuer Lagerzwecke). *Giessereipraxis (Berlin)*, vol. 50, nos. 20 and 21. May 19 and 26, 1929, pp. 77-79 and 81-83.

Properties and composition of bearing bronzes are discussed; pure copper-tin alloys can be improved by small additions of lead, zinc, and phosphorus; results of tests with high-grade lead bearing bronzes carried out by Ajax Metal Co.

BEARINGS, ANTI-FRICTION

Heavy-Duty Anti-Friction Bearings, S. G. Koon. *Iron and Steel (A. S. M. E. Trans.)*, vol. 51, no. 8, Jan.-Apr. 1929, pp. 5-16 and (discussion), pp. 16-20, 12 figs.

Advantages of ball or roller bearings on almost all types of operating mechanisms; limitations to use of bearings particularly those dealing with space limitation on equipment of old design; concurrent development of heavy-duty bearings for steel-rollingmill work along with backed-up types of rolling mills is traced; many features of operating conditions found in steel mills are discussed in their relation to use of bearings of this type; lubrication and care of bearings considered.

BRONZE. Bearing Bronzes with and Without Zinc, H. J. French and E. M. Staples. *U. S. Bur. Standards—Jl. of Research*, vol. 2, no. 6, June 1929, pp. 1017-1038, 22 figs.

Based on hardness tests, Izod impact tests, repeated pounding tests, and wear tests, both with and without lubrication, at temperatures within range 70 to 600 deg. Fahr., bronzes in copper corner of copper-tin-lead system have been classified according to character of service for which they seem to be best adapted; bronzes with less than 4 per cent tin unsuited for general bearing service; bronzes containing more than 5 per cent lead best able to operate for short periods in absence of lubrication.

BRONZE. Phosphorus Causes Hard Spots in Bearing Bronzes, J. Silberstein. *Foundry*, vol. 57, no. 15, Aug. 1, 1929, pp. 672-673.

Causes of defects in bearing bronzes forming hard spots are discussed; excess phosphorus in metal is oxidized, forming fusible slag, which attacks and fuses to sand and refractories.

BLOOMING MILLS

BILLET HANDLING. Straightens and Surfaces Billets on Specially Designed Machines, L. Cammen. *Iron Trade Rev.*, vol. 85, no. 2, July 11, 1929, pp. 79-81, 3 figs.

Description of billet chipping machine which consists of two units, surfacer and straightener; billet surfacer is essentially planer with peculiar type of tool; appreciable reductions in both time and labor factors are effected by use of new billet-handling units; procedure described.

BOILER PLATES

CRACKING. Mechanical Stresses Seen as Chief Cause of Cracks in Boiler Plate, J. C. McCabe. *Power*, vol. 70, no. 4, July 23, 1929, pp. 148-149, 1 fig.

Causes of cracking can be traced to design and workmanship; caustic soda, long joints plates often transversely loaded, and also to caustic or other precipitates found between plates of joint. Paper read before

Nat. Board of Boiler and Pressure Vessel Inspectors.

EMBRITTLEMENT. Recent Developments in Boiler-Metal Embrittlement, H. F. Rech. *Mech. Eng.*, vol. 51, no. 8, Aug. 1929, pp. 589-593, 14 figs.

Early investigation of causes of embrittlement; all cracking in boiler plates and tubes is not caused by caustic embrittlement; cracks developed in drums and tubes are intercrystalline and found only in stressed metal; examples of cracking.

BRONZE CASTING

Practical Points from the Metallurgy of Cast Bronzes, H. C. Dews. *Foundry Trade Jl. (Lond.)*, vol. 40, no. 670, June 20, 1929, pp. 474-476, 4 figs.

Causes for failures in bronze founding are discussed; solidification process; contraction on freezing; temperature range of freezing; effect of other metals; fracture of bronze. Paper presented before Int. Foundrymen's Congress.

Nonferrous Foundry Metallurgists in Session, H. C. Dews. *Foundry Trade Jl. (Lond.)*, vol. 41, no. 675, July 25, 1929, pp. 68-70.

Discussion of paper entitled Practical Points from Metallurgy of Cast Bronzes, printed in June 20 issue of this journal; fracture judging; two types of contraction; equilibrium diagram as basis; phenomenon of "tin sweat"; cooperation between works and laboratory; remelted bronze borings; reclaimed scrap metal satisfactory.

CASE HARDENING

Welding Facts and Figures, D. Richardson. *Welding Jl. (Lond.)*, vol. 26, no. 308, May 1929, pp. 142-143 and 146 and 148, 1 fig.

Use of oxyacetylene flame for case-hardening purposes and precautions necessary; surface hardening by blowpipe; nitrogen hardening; nonferrous metals and alloys; aluminum and aluminum alloys; composition of aluminum-alloy castings.

The Case-Hardening of Carbon Steel for Automobile Purposes, H. Swain. *Automobile Engr. (Lond.)*, vol. 19, no. 255, June 1929, pp. 226-230, 6 figs.

History of case hardening briefly reviewed; changes in carbon steel on heating and quenching; methods of case hardening; nitrogen case hardening; theory of case hardening; usual faults and how to detect and eliminate them; local hardening; testing by Brinell and Firth Hardometer.

CAST IRON

Ingot Molds Made of Improved Iron. *Blast Furnace and Steel Plant*, vol. 17, no. 8, Aug. 1929, pp. 1174-1175, 3 figs.

After years of research, cast iron of superior qualities is produced which when used for manufacturing ingot molds greatly extends their life and service.

High-Strength Cast-Iron, O. Smalley and D. P. Forbes. *Soc. Automotive Engrs. Jl.*, vol. 25, no. 2, Aug. 1929, p. 184.

Description of Meehanite, patented process consisting mainly in controlling scrap, which is melted in ordinary cupola, and in treating molten metal at ladle with cheap electric-furnace compound of calcium which controls carbon-monoxide balance in iron and causes deposition of graphite, without itself going into solution; gunite, wear-resistant iron also described. Abstracts.

ALLOY CLASSIFICATION. Classification of Gray Iron Alloys, J. W. Bolton. *Am. Mach.*, vol. 71, no. 2, July 11, 1929, p. 53.

Effects produced on gray iron by alloying elements and pouring temperatures are discussed; factors upon which cooling velocity depends. Abstract of paper presented before Am. Soc. Testing Matls.

CHROMIUM. The Influence of Chromium in Cast Iron, J. W. Donaldson. *Foundry Trade Jl. (Lond.)*, vol. 40, no. 671, June 27, 1929, pp. 489-492, 15 figs.

Investigation of influence of chromium on heat resistance and other properties of cast iron; reference to other investigations; cast irons used; heat-treatment changes; results obtained by chemical and mechanical tests; volume changes; elevated-temperature tests; thermal conductivity; corrosion tests. Paper presented before Int. Foundrymen's Congress.

GRAPHITIZATION. Graphitization of Prequenched White Cast Iron, H. A. Schwartz, H. H. Johnson, and C. H. Junge. *Am. Soc. Steel Treating—Preprint, for mtg.* Sept. 9-13, 1929, no. 1, 19 pp., 7 figs.

Study of acceleration of graphitization produced by prequenching of hard iron before annealing; reactions involved are interfacial in character and represent rate of solution of cementite in metallic matrix; diffusivity of carbon in iron not necessarily altered by prequenching operation; migration of carbon much accelerated due to greatly increased number of graphite nuclei; data show no ground for assuming that prequenching alone increases carbon content of phase which appears to be cementite.

GRAPHITIZATION. Some Theories of Graphitization, H. A. Schwartz. *Foundry Trade Jl. (Lond.)*, vol. 41, no. 675, July 25, 1929, pp. 58 and 60.

Effect of decomposition of cementite; influence of gas reactions; influence of alloys; limit of graphitization range.

GRAPHITIZATION. The Influence of Graphitization of Cast Iron, E. Diepschlag. *Foundry Trade Jl. (Lond.)*, vol. 41, no. 673, July 11, 1929, pp. 23-26, 13 figs.

Inherent properties of cast iron; overcoming inherency; how blast furnace conditions affect final product; influence of remelting; graphite; importance of nuclei; identification of graphite types; experimental evidence; interesting structures from diverse sources; conditions of graphite and transverse strength; result of sequestration of foundries. Paper presented before Int. Foundrymen's Congress.

HEAT TREATMENT. Heat Treatment of Various Types of Iron Castings. *Fuels and Furnaces*, vol. 7, no. 8, Aug. 1929, pp. 1173-1174 and 1182.

Discussion of results of investigation into various phases of, and objects for, heat treatment of cast iron.

NICKEL. Recommended Practice Committee Releases, P. D. Merica. *Am. Soc.*

for Steel Treating—TRANS., vol. 16, no. 2, Aug. 1929, pp. 314-327, 1 fig.

Effect of nickel on gray iron; machinability and structure; step bar test; uses of nickel iron.

NICKEL CONTENT. The Practical Application of Nickel in Cast Iron, A. B. Everest. *Foundry Trade Jl.* (*Lond.*), vol. 41, no. 675, July 25, 1929, pp. 61-64 and 67, 9 figs.

Current situation in development of alloy irons containing nickel and some of results now being obtained; application of nickel in cast iron; advantage of using nickel in foundry; uniformity of product; soundness of heavy sections; function of chromium; influence of nickel on machinability; properties of nickel cast iron; improved wear; improved mechanical properties; machinable hardness. Paper presented before Int. Foundrymen's Congress.

STEEL ADDITIONS. Carbon Content and Accompanying Properties of Gray Cast Iron Produced in Cupola According to Steel-Addition Process (Ueber den Kohlenstoffgehalt und die damit zusammenhaengenden Eigenschaften des im Kupolofen nach dem Stahlgussverfahren erzeugten Graugusses), K. Emmel. *Giesserei* (*Duesseldorf*), vol. 16, no. 27, July 5, 1929, pp. 605-612, 16 figs.

Factors which influence physical values, such as carbon content cupola design and operation, etc., are discussed; reliability of process is demonstrated.

CAST IRON ANALYSIS

Strength and Burdens of Cupola Melted Cast Iron (Festigkeiten und Gattierungen des Gusseisens im Kupolofen erschmolzen), W. Schreck. *Zeit. fuer die Gesamte Giessereipraxis* (*Berlin*), vol. 50, no. 24, June 16, 1929, pp. 205-206, 6 figs.

Calculations of analyses and burdens are discussed based on which approximate strength values of cast iron are determined; constituents and their behavior in iron are discussed.

CAST IRON PROPERTIES

Elasticity and Oscillating Strength of Cast Iron (Die Elastizitaet und die Schwingungsfestigkeit des Gusseisens), A. Thum and H. Ude. *Giesserei* (*Duesseldorf*), vol. 16, no. 24, June 14, 1929, pp. 547-556, 15 figs.

Bending strength and other properties of cast iron are discussed; conclusions based on results of tests. (Concluded.)

CAST IRON TESTING

Physical Tests for Cast Iron, J. Shaw. *Iron and Steel Industry* (*Lond.*), vol. 2, no. 11, Aug. 1929, pp. 345-347.

Review of papers presented at International Foundrymen's Conference on subject; history of test specifications; discussion of three specifications that have been suggested as basis for international standard; composition in relation to size of test bar; relation of shear strength to tensile and transverse strength.

Methods of Testing Cast Iron, A. le Thomas and R. Bois. *Foundry Trade Jl.* (*Lond.*), vol. 41, nos. 673, 674 and 675, July 11, 18 and 25, 1929, pp. 19-21 and 32, 46-48 and 50 and 65-67, 12 figs.

July 11: Description of how machinery casting ought to be tested; mechanical tests capable of determining intrinsic characteristics of cast iron; criticisms of shear test. July 18: Application of Frémont tests to castings. July 25: Criticism of methods outlined; testing castings on separate bars; special conditions for extra-strong castings. Paper presented before Int. Foundrymen's Congress.

A. S. T. M. Studies Cast Iron. *Foundry*, vol. 57, no. 14, July 15, 1929, pp. 608-612.

Review of Atlantic City meeting of American Society for Testing Materials with abstracts of papers presented; methods for expediting standardization procedure proposed in report of Committee; 11 papers given in symposium on physical properties of cast iron; methods of testing metals; die casting data; corrosion and fatigue.

COPPER ALLOYS

CRYSTALLOGRAPHY. Flowing of Metal Crystals Produced by Torsion (Das Fliessen von Metallkristallen bei Torsion), R. Karnop and G. Sachs. *Zeit. fuer Physik* (*Berlin*), vol. 53, Feb.-Mar. 1929, pp. 605-618, 7 figs.

Five per cent copper-aluminum alloy was studied under torsion and experiments were interpreted from crystallographic point of view and compared with stretching experiments of authors.

DENSITY. On the Relation Between the Lattice-Constant and the Density of Solid Solutions, S. Sekito. *Tohoku Imperial University—Science Reports* (*Sendai*), vol. 18, no. 1, May 1929, pp. 61-68, 2 figs.

Paper contains results of determination of lattice-constant of several series of solid solution containing copper; density of these alloys, as given by direct measurement, is always greater than those given by additive law, but coincides satisfactorily with those calculated from observed lattice-constant. (In English.)

COPPER HARDENING

Hardening Copper and Outdoing the Ancients, W. G. Schneider. *Iron Age*, vol. 124, no. 2, July 11, 1929, p. 96.

What modern metallurgy has done in copper hardening is discussed; two methods of hardening copper by alloying and cold working; Brinell hardness testing; no comparison with steel. From Research Narratives, vol. 7, no. 7, of United Eng. Soc.

COPPER PLATING

Rapid Electrolytic Coppering of Steel on Thin Layer of Nickel. *Metal Industry* (*Lond.*), vol. 34, no. 26, June 28, 1929, p. 641.

Procedure for electrodepositing copper on steel by aid of thin intermediate coating of nickel is outlined. From *Revue de Métallurgie*, Apr. 1929.

COPPER SMELTING

Copper Converter Practice, A. J. Caddick. *Metal Industry* (*Lond.*), vol. 35, no. 3, July 19, 1929, pp. 51-53.

Results of investigations to enable ascertainment of grade of matter for most economical production, which show considerations arising under different conditions of practice; tables given relate to investigations conducted over 121 converter blows and represent treatment of some 3903 tons of matter.

CUPOLAS

FUEL ECONOMY. Fuel Economy in the Cupola, N. D. Ridsdale. *Iron and Steel of Canada (Gardenvale, Que.)*, vol. 12, no. 7, July 1929, pp. 179-180, 2 figs.

Essential points which are stated as contributing to fuel economy are quality of cokes, thickness of layer of fusion coke, regularity of charging, height of coke bed, volume of blast, and size of tuyeres.

HOT BLAST. The Hot-Blast Cupola, F. K. Vial. *Iron and Steel (A. S. M. E. Trans.)*, vol. 51, no. 8, Jan.-Apr. 1929, pp. 21-30, 3 figs.

Present status of cupola practice is discussed; fuel economy; and heat losses in cupola operation due to radiation, slag, liberating carbon dioxide, moisture and waste gases; heat available for melting after making deductions; heat lost in cold-blast cupola because of large amount of carbon monoxide produced; hot-blast heat balance; comparison of cold-blast and hot-blast cupolas; melting capacities of and air requirements for cupolas of various capacities; blast pressure; advantage of hot blast in cupola practice.

DIE CASTING

Die Casting, A. H. Mundey. *Foundry Trade Jl. (Lond.)*, vols. 40 and 41, nos. 671 and 672, June 27 and July 4, 1929, pp. 486-487 and 9-11, 7 figs.; see also *Metal Industry (Lond.)*, vol. 35, no. 1, July 5, 1929, pp. 9-11.

June 27: Die casting defined; slush, centrifugal and Corthias casting are outlined; present die-casting process; application of plunger-type machine; permanence of zinc-base die castings. July 4: Tubular die castings; physical and mechanical properties of copper-rich alloys, and magnesium alloys. Paper presented before Int. Foundrymen's Congress.

Die Casting, A. H. Mundey. *Metal Industry (Lond.)*, vol. 35, no. 2, July 12, 1929, pp. 31-34.

Results of investigation of die casting five alloys, conducted by National Physical Laboratory; investigation of copper-rich alloys for die casting; comparison with industrial alloys; commercial production of die castings. Paper presented at Annual Convention of Inst. Brit. Foundrymen. (Concluded.)

DIE CASTING ALLOYS

Die-Casting Alloys and How to Select Them. *Machy. (Lond.)*, vol. 34, no. 871, June 20, 1929, p. 378.

Information compiled by Alemite Die-Casting and Manufacturing Co., Chicago, with view to helping user of die-castings to select alloys from which different castings should be made; physical properties given from table; tolerances for alloys.

DURALUMIN

Some Uses of Duralumin, F. Grove-Palmer. *Metal Industry (Lond.)*, vol. 34, no. 25, June 21, 1929, p. 610.

Growing uses of duralumin are discussed; annealing process; special precautions in heat treating duralumin rivets.

WELDING. Welding Duralumin. *Aviation Eng.*, vol. 2, no. 7, July 1929, p. 14.

Discussion of correct practices for making welded joints in 17S strong aluminum alloy; properties due to composition, heat treating, aging, and working; making duralumin tanks; production of joints made in duralumin without heat treating. Article previously indexed from Oxy-Acetylene Tips.

ELECTRIC FURNACES

ANNEALING. Electric Annealing of Magnetic Materials for Telephone Apparatus, W. B. Cooley. *Fuels and Furnaces*, vol. 7, no. 7, July 1929, pp. 1023-1024 and 1065-1066. Car-bottom electric furnaces of recuperative type anneals 6 tons of magnetic parts daily; operation is described. From paper presented at Indus. Heat School, Nat. Elec. Light Assn.

HEAT TREATING. Automatic Electric Furnace for Heat Treatment of Steel (Four électrique automatique pour le traitement thermique des pièces d'acier). *Jl. du Four Electrique (Paris)*, vol. 38, no. 6, June 1929, pp. 189-190, 1 fig.

Details of Ugine-Infra furnace, merits of which lie in simplicity of its design and its safe operation; it is equipped with rheostat for regulation independent of temperature.

Development of Electric Furnaces for Heat Treating Operations Above 1800 Deg. Fahr., K. J. Kuhlmann. *Fuels and Furnaces*, vol. 7, no. 7, July 1929, pp. 1001-1004.

Development, operation, and maintenance of electric furnace for forging, using non-metallic resistors; carbon-trench type of electrically heated furnace; electrically heated tunnel kilns. Abstract of paper presented at Indus. Heat. School, Nat. Elec. Light Assn.

Electrical Furnaces for the Heat Treatment of Steel. *Iron and Steel Industry (Lond.)*, vol. 2, no. 10, July 1929, p. 339, 1 fig.

Description of electric furnaces for heat treating steel; requirements of furnace; construction and operation of Wild-Barfield industrial electric furnaces are discussed.

Heat Treating Gears. *Automobile Engr. (Lond.)*, vol. 19, no. 255, June 1929, pp. 215-217, 5 figs.

Description of new rotary annular-hearth electric furnace for continuous operation in plant of Moss Gear Co.; entire furnace is heavily heat insulated, sides and roof with natural and C.22 Sil-o-Cel brick and roof with Sil-o-Cel powder; electric equipment and method of operation described in detail.

Applications of Electricity in Heat Treatment, A. N. Otis. *Can. Machy. and Mfg. News (Toronto)*, vol. 40, no. 15, July 25, 1929, pp. 40-42, 10 figs.

Types of furnaces are described suitable for heat treating steel forgings and machine parts, such as are used in manufacture of automobiles, agricultural implements, etc.;

types described are rotary hearth, multiple track, pusher-type tunnel furnaces and counter flow furnace; these may be used for normalizing, annealing, carburizing, hardening and tempering.

Fan Incorporated in New Electric Air Drawing Ovens. *Gen. Elec. Rev.*, vol. 32, no. 8, Aug. 1929, p. 423.

New air drawing oven, for drawing carbon steel at temperatures up to 750 deg. Fahr. improves quality and increases production as result of use of fan for agitating air around work.

ELECTRIC FURNACES, HIGH FREQUENCY

Operates Four Induction Furnaces. *Iron Trade Rev.*, vol. 85, no. 1, July 4, 1929, pp. 24-25, 2 figs.

Results and experiences obtained with four Ajax-Northrup coreless induction furnaces installed in foundry of Babcock and Wilcox Tube Co. at Beaver Falls, Pa., in Jan. 1927; different alloys run in furnaces are given; foundry obtained exact control of special alloy analyses.

High Frequency Furnace Used in Melting Alloy Steels. *Fuels and Furnaces*, vol. 7, no. 7, July 1929, pp. 1029-1031, 3 figs.

Four coreless induction-type furnaces, two holding 400 lb. each and two holding 1000 lb. each, installed in foundry of Babcock and Wilcox Co. for melting heat-resisting alloys and high-speed steels.

German Study of High-Frequency Steel Furnaces, H. Neuhauss. *Iron Age*, vol. 124, no. 3, July 18, 1929, p. 172.

Results of systematic investigation of metallurgy of high-frequency induction furnace in progress in Kaiser Wilhelm Institute fuer Eisenforschung in Duesseldorf, Germany; larger furnace means lower power per ton need; advantageous for low-carbon steels; duplexing with cupola. Abstract of article in *Stahl u. Eisen*, May 9, 1929.

The Work of British Institute of Metals (Les travaux de l'Institut anglais des Metaux). *Revue de Fonderie Moderne (Paris)*, vol. 23, May 10, 1929, pp. 178-182.

Abstracts of papers presented before London meeting of British Institute of Metals, including Recent Developments in Electric Furnaces, D. F. Campbell, Improvements in Electric Resistance Furnaces, W. Rosenhain and W. E. Pryherch, and Tests of Electrolytic Deposits on Aluminum, G. B. Brook and G. H. Stott, and other papers.

RESISTANCE. Industrial Electric Heating, N. R. Stansel and C. Dantsizen. *Gen. Elec. Rev.*, vol. 32, no. 8, Aug. 1929, pp. 448-453, 4 figs.

Dalton's and Avogadro's laws; fundamental statements in regard to effect of pressure on gas reaction, dissociation of water vapor and hydrogen as affected by pressure, equilibrium curves for reaction, Sauveur's chart of effect of pressure on carburizing iron. (To be continued.)

RESISTANCE. An Improved Form of Electric Resistance Furnace, W. Rosenhain and W. E. Prytherch. *Iron and Steel of Canada (Gardenvale, Que.)*, vol. 12, no. 7, July 1929, pp. 181-182.

Electric resistance furnace is described for which advantages are claimed in regard to higher available working temperatures up to 1400 deg. Cent., durability, and freedom from oxidation of carbon resistor; heating element of this type of furnace consists of carbon or graphite pellets, or short rods placed end to end in refractory sheathing tube which fits easily over them; heating occurs by contact resistance; sheathing tube prevents access of air sufficiently to avoid any appreciable burning of carbon.

ELECTROPLATING

The Principles of Electrochemistry Applied to Electrodeposition, S. Field. *Metal Industry (Lond.)*, vol. 34, no. 26, June 28, 1929, pp. 629-630, 2 figs.

Migration of ions is discussed; Hittorf's method; transference numbers. (Continuation of serial.)

FURNACES

CARBURIZING, GAS-FIRED. Gas in the Carburization of Iron and Steel, R. G. Guthrie. *West. Gas*, vol. 5, no. 7, July 1929, pp. 32-33 and 44, 2 figs.

Average size furnace consists of large cylindrical retort of one of nickel-chromium alloys about 15 by 48 in. inside dimensions; this retort has small gas inlet in back and readily removable gas tight cover over front; carburizing medium may be special or city gases, or gas evolved from small amounts of compound thrown into retort; by using city gas as carburizing medium, operation is possible. Paper presented before West. Metal Congress.

HEAT TREATING. Furnaces in Modern Bolt and Nut Plant, J. B. Nealey. *Heat Treating and Forging*, vol. 15, no. 6, June 1929, pp. 762-763.

Description of heat-treating furnaces in plant of Buffalo Bolt Co., North Tonawanda, New York, which are employed for manufacturing nuts and bolts; furnaces designed to facilitate mass production with minimum of labor; billet-heating furnace gas fired; hot-formed bolts and nuts; threading and tapping; final heat treatments accomplished in special heating machines; heating sucker rods for forging ends.

HEAT TREATING, GAS FIRED. The Gas Furnace in Relation to Heat Treatment, F. H. Trembly, Jr. *Engrs. and Eng.*, vol. 46, no. 7, July 1929, pp. 157-161, 5 figs.

Satisfactory performance and economics are determining factors in selection of fuel for heat treating furnaces; comparison of operation of gas and electric furnaces; author contends that gas furnace, with necessary proportioning and control equipment, satisfactorily meets exacting demands of steel treating. Abstract of paper presented before Am. Soc. for Steel Treating.

Low Pressure Gas Apparatus for Temperatures up to 1000 Deg. Cent., G. R. Hems. *Gas World (Lond.)*, vol. 91, no. 2346, July 20, 1929, (Industrial Gas Supp.), pp. 101-104, 4 figs.

Details of design are presented for furnaces for ferrous and nonferrous annealing operations, steel reheating, enameling and other uses.

Heat Treatments in Making Harvesters,

C. W. Geiger. *Heat Treating and Forging*, vol. 15, no. 6, June 1929, pp. 759-761, 5 figs.

Discussion of how gas facilitates hardening and carburizing of parts of grain harvesting machinery as manufactured on Pacific coast; Stockton Plant of Western Harvester Co. described; material-handling methods; assembling and shipping machines.

INDUSTRIAL. Furnaces and Equipment. *Am. Mach.*, vol. 71, no. 3, July 18, 1929, pp. 106-107, 8 figs.

Semi-annual review of furnaces and equipment described in Materials, Parts and Equipment Sections of magazine during first six months of 1929 is given, including vitreous enameling furnace, punch forge, copper-brazing furnace, electric drawing oven, nonoxidizing furnace, diamond block for hardening steel, and pyrometers.

INDUSTRIAL, GAS. Gas as an Industrial Fuel in California, A. L. Bolton. *Heat Treating and Forging*, vol. 15, no. 6, June 1929, pp. 764-765, 2 figs.

Numerous instances are cited showing advantages of gas as fuel in heating and heat treating; capacity for proper regulation is advantage; clean working conditions, progress in California is marked; fuel trend in railroad shops; annealing of plates; oil fuel replaced by gas.

MELTING, GAS FIRED. Gas Fired Furnaces Used in Melting Alloys for Die Casting, J. B. Nealey. *Fuels and Furnaces*, vol. 7, no. 7, July 1929, pp. 1083-1085, 3 figs.

At plant of Stewart Die Casting Corp., Chicago, Ill., 20 soft-metal furnaces, ranging in size from 100 to 4000 lb. per charge, supply white alloys used in die casting variety of small parts for automobiles, tractors, telephones and other units.

METALLURGICAL, GAS FIRED. Application of Municipal Gas or Water Gas in Melting of White Metal (L'emploi du gas de ville ou du gaz pauvre pour la fusion des métaux blancs). *Revue de Fonderie Moderne (Paris)*, vol. 23, May 10, 1929, pp. 188-192, 8 figs.

Type of modern mixing furnaces; advantages of using gas; results of tests; automatic temperature regulation; details of patented mixing furnace Monometer heated by oil.

METALLURGICAL — PULVERIZED COAL. Pulverized Coal in Steel Furnaces, W. O. Renkin. *Iron Age*, vol. 124, no. 3, July 18, 1929, pp. 155-156.

Results obtained with powdered fuel in metallurgical work are outlined, including iron blast, air, open-hearth, reheating, and annealing furnaces. Abstract of paper presented before Assn. Iron and Steel Elec. Engrs.

Application of Pulverized Coal to Metallurgical Furnaces, H. W. Hollands and E. C. Lowndes. *Foundry Trade Jl. (Lond.)*, vol. 41, no. 674, July 18, 1929, pp. 41-44 and (discussion) 44-45, 2 figs.

Basic principles essential to successful application of powdered fuel to metallurgical processes; specific applications, including skelping furnaces of Edward Smith, Ltd., billet furnace of F. R. Simpson and Co., plate-heating furnaces of Thomas Piggott and Co., and steel melting plants; economies effected; puddling furnaces. Paper presented before Int. Foundrymen's Congress.

HARDNESS TESTING

Hardness-Testing Methods (Die Technische Haertepruefung). M. Moser. *Kruppsche Monatshefte (Essen)*, vol. 10, June 1929, pp. 62-73, 33 figs.

Review of hardness-testing methods, with special consideration of Brinell ball-hardness method; auxiliary measuring equipment; types of automatic hardness testing machines; dynamic Brinell tester; Shore scleroscope, and Herbert pendulum tester.

The Hardness and Abrasion Testing of Metals, G. A. Hankins. *Engineer (Lond.)*, vol. 148, nos. 3835 and 3836, July 12 and 19, 1929, pp. 34-35 and 61-63, 2 figs.

Synopsis prepared by author; subject matter has necessarily been treated in very brief manner, and attention has been given to practical aspects in preference to speculative questions; indentation hardness tests, abrasion or wear tests, and search hardness tests have all been considered. Report before Instn. Mech. Engrs., Hardness Tests Research Committee. (To be continued.)

The Hardness and Abrasion Testing of Metals, G. A. Hankins. *Engineer (Lond.)*, vol. 148, no. 3836, July 19, 1929, pp. 61-63, 2 figs.

Diamond indentation tests; chart for comparison of Brinell, Rockwell, and diamond pyramid scales; steel cone indentation test; Herbert pendulum hardness tester; dynamic indentation tests; meaning of indentation tests. (Continuation of serial.)

The Hardness and Abrasion Testing of Metals, G. A. Hankins. *Engineer (Lond.)*, vol. 148, no. 3837, July 26, 1929, pp. 90-92, 2 figs.

Abrasion of wear tests; metal-to-metal tests by Bureau of Standards; diamond scratch hardness tests; Hertzian hardness; magnetic hardness tests. (Concluded.)

HEAT TREATMENT EQUIPMENT

Heat Treatment Equipment. *Machy. (Lond.)*, vol. 34, nos. 871 and 872, June 20 and 27, 1929, pp. 361-363 and 389-392, 15 figs.

June 20: Description of producer-gas tube-annealing furnace; hexagonal recuperator annealing furnace manufactured by Incandescent Heat Co., Smethwick, for annealing solid-drawn seamless-steel tubes for aircraft. June 27: Description of Bright annealing-tube furnace; annealing brass strip; electric-furnace heating elements; rock drill furnace.

IMPACT TESTING

REPEATED BLOW. Repeated Blow Impact Tests, R. H. Greaves. *Metallurgist (Supp. to Engineer, Lond.)*, June 28, 1929, pp. 88-90, 5 figs.

Investigation made to determine what extent brittleness revealed blow impact tests on notched bars; assuming that tensile and single-blow notched-bar test have been made on a material, it is doubtful whether results of repeated-blow tests add any information

of value; test, however it is carried out, is too complex to have any simple quantitative significance. (Concluded.)

IRON, PURE

On the Double Diagram of the Iron-Carbon System, K. Honda. *Am. Soc. for Steel Treating*—TRANS., vol. 16, no. 2, Aug. 1929, pp. 183-190, 1 fig.

Since direct precipitation of graphite from melt is very doubtful, and result of X-ray analysis does not accord with consequences of double diagram, author concluded that for pure iron-carbon system, single diagram is simplest and most satisfactory one. Read before West. Metal Congress.

IRON ALLOYS

ANALYSIS. Iron-Beryllium and Iron-Boron Alloys; the Structure of Iron Boride (Ueber Eisen-Beryllium- und Eisen-Bor-Legierungen und ueber die Struktur des Eisenborides), F. Wever. *Zeit. fuer technische Physik* (*Leipzig*), no. 4, 1929, pp. 137-138, 2 figs.

Phase diagrams of iron-beryllium, iron-boron, and iron-carbon are compared; carbon enlarges range of gamma iron considerably; action of boron and beryllium is reversed, cause of these differences being found in increasing atom radium of these elements.

X-RAY ANALYSIS. X-ray Investigation of Iron and Nitrogen Alloys, A. Osawa and S. Iwaizumi. *Tohoku Imperial Univ.—Science Reports* (*Sendai*), vol. 18, no. 1, May 1929, pp. 79-89, 4 figs.

Investigation of equilibrium diagram of iron and nitrogen system by magnetic analysis and microscopic investigation; two compounds found on iron side: present investigation was undertaken to determine atomic arrangement of these compounds. (In English.)

IRON CASTINGS

DEFECTS. Cause of Blowholes in Heavy Castings (Entstehungsursache von Gasblasen bei schweren Gusstuecken), J. Gaebel. *Zeit. fuer die Gesamte Giessereipraxis* (*Berlin*), vol. 50, no. 25, June 23, 1929; p. 215.

Blowholes are due chiefly to three causes: (1) gases already in dissolved form in pig iron; (2) gases which are absorbed in molten iron by melting process in shaft furnace; (3) shrink cavities and blowholes formed in molds by water vapor, graphite separation, etc.; preventive means are discussed.

IRON CORROSION

Ferroxyl Indicator (Ueber den Ferroxyl-Indikator), W. van W. Scholten. *Korrosion u. Metallschutz* (*Berlin*), vol. 5, no. 3, Mar. 1929, pp. 62-64, 2 figs.

Results of author's experiences with use of ferroxyl indicator; its use in simplified form is convenient and no troubles are experienced under ordinary conditions, used in manner described.

IRON CRYSTALS

MAGNETIC MEASUREMENTS. Magnetic Measurements on Iron Single Crystals and Groups of Crystals with New Magnetic Potential Meter (Magnetische Messungen an Eisenviel- und Eiseneinkristallen mit einen neuartigen magnetischen Spannungsmesser), H. Gries and H. Esser. *Archiv fuer Elektrotechnik* (*Berlin*), vol. 22, no. 2, June 15, 1929, pp. 145-152, 7 figs.

Arrangement of apparatus; influence of nitrogen, hydrogen, and oxygen in magnetic properties is expressed in curves.

IRON FOUNDRY PRACTICE

Applies Scientific Data to Problems Encountered in Foundry Work, F. Hudson. *Foundry*, vol. 57, no. 15, Aug. 1, 1929, pp. 643-647, 7 figs.

Importance of scientific data in foundry operation is emphasized; composition of iron, cupola operation, carbon control and pouring practice and other factors govern production of sound castings; example of casting locomotive cylinders; total carbon control. Abstract of paper presented before Am. Foundrymen's Assn. (To be concluded.)

IRON INCLUSIONS

Inclusions in Iron, C. R. Wohrman. Cleveland, American Society for Steel Treating, 1928, 162 pp., illus., $3.00.

This research is essentially photomicrographic study of inclusions created in iron by oxygen, sulphur, and manganese, undertaken as contribution upon problem of how to govern these inclusions; author first described in detail methods used in making artificial known inclusions and in preparing and examining specimens; he then gives account of results obtained, and presents conclusions reached. Eng. Soc. Lib.

IRON METALLOGRAPHY

Experimental Data on the Equilibrium of the System Iron Oxide-Carbon in Molten Iron, A. B. Kinzel and J. J. Egan. *Am. Inst. Min. and Met. Engr.—Tech. Pub.*, no. 230, for mtg. Sept. 1929, 9 pp., 3 figs.

Method of determination of equilibrium constant is described; electrolytic iron was used; materials and apparatus; procedure; new value for m, weight-concentration equilibrium-constant, is found.

Influence of Elements on the Polymorphism of Iron (Der Einfluss von Elementen auf den Polymorphismus des Eisens), A. Heinzel. *Zeit. fuer technische Physik* (*Leipzig*), no. 4, 1929, pp. 136-137, 2 figs.

Boundaries of field of gamma iron of face-centered structure (normally from 906 to 1401 deg.) are influenced by admixtures; all elements of large atom radium, alkali and earth alkali metals, hydrogen, lead, bismuth, silver, etc., are insoluble in iron.

IRON AND STEEL

OXYGEN DETERMINATION. Determination of Oxide Inclusions in Iron and Steel by Analytical Methods by Means of Chlorine Decomposition (Bestimmung der oxydischen Einschluesse in Eisen und Stahl auf rueckstandsanalyttischem Wege durch Chloraufschluss), R. Wasmuht and P. Oberhoffer. *Archiv fuer das Eisenhuettenwesen* (*Duesseldorf*), vol. 2, no. 12, June 1929, pp. 829-842, 26 figs.

Notes on chlorine-gas purification and volatilization; study of decomposition of

residual constituents in chlorine, alone, and in presence of carbon; influence of phosphorus and sulphite; conditions governing investigation and results obtained.

Determination of Gases in Metals, Especially Oxygen in Iron and Steel According to Hot-Extraction Process (Zur Bestimmung der Gase in Metallen, etc.), H. Diergarten. *Archiv fuer das Eisenhuettenwesen (Duesseldorf)*, vol. 2, no. 12, June 1929, pp. 813-828, 23 figs.

Principles governing development of new furnaces for hot-extraction process are discussed; results of new tests with refractory crucibles of oxidic mass; application of Acheson graphite crucibles in new furnaces; different types of furnaces are described and compared with each other and with high-frequentcy furnaces.

MALLEABLE IRON CASTINGS

Malleable Cast Iron, W. T. Evans. *Metallurgist (Supp. to Engineer, Lond.)*, June 28, 1929, pp. 96.

Letter to editor referring to article in Apr. 26 issue of this journal, p. 96; writer was for some years manager for one of oldest manufacturers of whiteheart malleable in England, and did everything possible to control scientifically process throughout, but without much success; most malleable troubles arise from composition, if this is under control within close limits, annealing is comparatively easy proposition, providing that in whiteheart castings are of uniform minimum section. Includes brief reply of author of above mentioned article.

Malleable Cast Iron, C. H. Plant. *Iron and Steel Industry (Lond.)*, vol. 2, no. 10, July 1929, pp. 333-334.

Subject of annealing malleable cast iron is continued with practical details of methods of conducting process; need of pyrometric control; preparatory treatment of castings; grinding rough castings; defects in malleable cast iron hard spots. (To be concluded.)

The Malleable Cast Iron (La fonte malleable), M. Godefroid. *Revue de Fonderie Moderne (Paris)*, vol. 23, June 25, 1929, pp. 243-251, 1 fig.

History and definition of malleable cast iron; variations in structure of white iron; methods of producing malleable cast iron readily for commercial purposes; composition of white iron for malleable black-heart castings, and for French malleable iron; various cupolas and reverberatory and electric furnaces; annealing; straightening; comparison between Réaumur cast iron and black-heart iron; American malleable iron.

SPECIFICATIONS. Malleable Iron Castings. *Am. Ry. Assn.—Signal Section Proc.*, vol. 27, no. 1, Aug. 1929, pp. 238-240.

Recommended specifications for malleable iron castings for railway signaling.

METALLOGRAPHY

Metallography Simplified for Practical Use in Shop, E. Preuss, G. Berndt and M. v. Schwarz. *Iron Trade Rev.*, vol. 85, no. 6, Aug. 8, 1929, pp. 328-330, 7 figs.

Other methods of testing metals which supplement microscopic testing methods are outlined; determining of heat expansion by dilatometer; dynamic testing of materials; hardness tests; drop hardness tester; magnetic testing of steel; notched-bar impact test for testing brittleness. (Concluded.)

Metallography Simplified for Practical Use in Shop, E. Preuss, G. Berndt and M. v. Schwartz. *Iron Trade Rev.*, vol. 85, no. 2, July 11, 1929, pp. 82-83, 4 figs.

Microscopic examination of inclusions, slags, and welding seams are discussed; method of determining whether rail ends had been welded together within joint; examination of high-speed steel twist drills electrically butt welded onto ordinary carbon steel. (Concluded.)

METALS

ANALYSIS—REAGENTS. A New Reagent of Macroscopic Metallography (Un nouveau réactif de métallographie macroscopique), G. d'Huart. *Revue de Métallurgie (Paris)*, vol. 26, no. 6, June 1929, pp. 300-306, 13 figs.

Notes on use of nickel-base reagent, developed by author, which, it is claimed, gives surprisingly good results; it is composed of distilled water, concentrated hydrochloric acid, crystallized chromic acid, and chloride of nickel anhydride; it is especially applicable to mild steel, cast iron, copper and its alloys.

CALORIZING. Protective Treatment of Metal Parts Subjected to High Temperature. *Mech. World (Manchester)*, vol. 85, no. 2217, June 28, 1929, p. 607.

Methods of calorizing different metals for protection against oxidation and destructive effects of corrosion at high temperatures described; process consists of formation of surface alloy of aluminum, not as coating, but forming solid alloy for certain depth; aluminum is thoroughly fused into exposed portions of metal.

COLD WORKING. Strain Hardening Effects in Cold Worked Metals, E. V. Crane. *Metal Stampings*, vol. 2, no. 7, July 1929, pp. 505-510, 6 figs.

Properties of metals as indicated by physical test data and their changes which have to do with drawing operations.

Texture of Cold-Worked Metals (Beitraege zur Kenntnis der Textur kaltverformter Metalle), F. Wever and W. E. Schmid. *Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung (Duesseldorf)*, vol. 11, no. 7, 1929, 122 pp., 53 figs.

Determination of texture of parallelpiped-plane deformation of aluminum and iron; X-ray-analysis method; formation of texture with increasing deformation; determination of pole figures at higher deformation with aid of graphic networks; deformation of single crystals of cubic surface-centered metals and application to cubic space-centered metals; significance for rolling process.

DENSITY. On the Density of Molten Metals and Alloys, Y. Matuyama. *Tohoku Imperial Univ.—Science Reports (Sendai)*, vol. 18, no. 1, May 1929, pp. 19-46, 14 figs.

Density of five molten metals and six ternary alloys; measured at different temperatures by methods devised by author. (In English.)

PLASTICITY. On the Theory of the

Plasticity of Metals, H. Shoki. *Tohoku Imperial Univ.—Science Reports (Sendai)*, vol. 18, no. 1, May 1929, pp. 1-9.

Theoretical investigation upon plasticity of metals, assuming principle of superposition. (In English.)

STRAIN ANALYSIS. Rise of the Break in Tensile-Strength Curve of Metals Due to Strain and Aging (Sur le relèvement du palier de la courbe de traction des métaux par traction et vieillissement) Galibourg, *Académie des Sciences—Comptes Rendus (Paris)*, vol. 188, no. 15, Apr. 8, 1929, pp. 993-995.

Curves are given representing variation of rise for extra-soft steel as function of time; rate of rise increased with temperature, temperatures of aging between first and second strains being 12.5-14.5 deg., 50-53 deg., and 175-180 deg., pure nickel aged at 175-180 deg. also showed phenomenon.

SULPHUR AFFINITY. Affinity of Sulphur for Metals (Die Verwandtschaft des Schwefels zu den Metallen), C. Frick. *Chemiker-Zeitung (Koethen)*, vol. 53, no. 32, Apr. 20, 1929, pp. 317-318.

Comparison of "affinity series" of metals for sulphur, as determined by Fournet, Markus, Schweder, Thomsen-Durre, Ostwald, Guertier and Frick; very general agreement in results is observed in spite of differences in methods of measurement used.

VISCOSITY. Study of Viscosity (Suite à l'étude de la viscosité), J. Cournot. *Revue de Métallurgie (Paris)*, vol. 26, no. 6, June 1929, pp. 326-328, 3 figs.

This work is continuation of study reviewed in 1925, 1926, and 1928 issues of this journal; tests were carried out on aluminum and duralumin and charts are given showing variation in rate of viscous flow and variation and limits of viscosity in function of temperature. See reference to earlier work in Eng. Index 1928, p. 1154.

Viscosity of Solids (Ueber die Zaehigkeit fester Koerper), S. Erk. *Zeit. fuer Metallkunde (Berlin)*, vol. 21, no. 6, June 1929, pp. 185-189, 2 figs.

Flow of solids, is discussed; stationary and periodic method of measuring viscosity; mechanism of internal friction in case of amorphous and crystalline materials.

METALS ANALYSIS

Use of Vitrified Silica Apparatus for the Determination of Metals as Sulphate (Sur le dosage des métaux à l'état de sulfates et l'emploi en analyse du matériel de silice vitrifiée), A. A. Guntz and J. Barbier, *Chimie et Industrie (Paris)*, vol. 21, no. 4, Apr. 1929, pp. 711-712, 1 fig.

Determination of different metals is described; determination of nickel and cobalt as sulphates is not recommended because permissible temperature range for ignition is too small.

ELECTROLYTIC. Electric Analysis with Mercury Cathodes (Ueber Elektroanalysen mit Quecksilberkathoden), W. Moldenhauer and K. F. A. Ewald and O. Roth. *Zeit. fuer angewandte Chemie (Berlin)*, vol. 42, no. 13, Mar. 30, 1929, pp. 331-334, 1 fig.

After describing theory and technique of electrolytic work with hydrogen cathode in spoon-shaped electrode, new procedures are described.

METALS CORROSION

The Distribution and Velocity of the Corrosion of Metals, U. R. Evans. *Franklin Inst.—Jl.*, vol. 208, no. 1, July 1929, pp. 45-58, 1 fig.

Account of recent researches conducted at Cambridge University, England, on corrosion and passivity of metals; how principles may be extended to consideration of velocity of corrosion; velocity of corrosion is function of oxygen supply and nature of metal.

Surface Oxidation of Aluminum, Tungsten and Molybdenum, L. C. Bannister. *Metal Industry (Lond.)*, vol. 35, no. 2, July 12, 1929, pp. 27-28 and 30.

Causes of surface oxidation of aluminum, tungsten and molybdenum are discussed; results of observations of attempt to produce in single sheet of each metal film varying in thickness in regular manner, and then to observe if optical color sequence were produced thereby; anodic film is oxide film of variable thickness, which can cause interference of light in visible region of spectrum and so produce color.

The Atmospheric Corrosion of Metals. *Metal Industry (Lond.)*, vol. 35, nos. 2 and 4, July 12 and 26, 1929, pp. 35-37 and 79-82, 2 figs.

July 12: Main weight-increment tests; calibration of stand; average thickness of corroded layer; gravimetric results; relative behavior of materials; copper-nickel and nickel-copper. July 26: Discussion of weight-increment by composition curves for copper-nickel alloys; influence of deliquescence of corrosion product in determining corrosion in Stevenson screen; tests by electrical resistance method; loss in weight tests; general discussion of results. Experimental report to Atmospheric Corrosion Research Committee, presented before Faraday Soc. (Concluded.)

METALS FATIGUE

Fatigue Tests of Large Specimens, R. E. Peterson. *Am. Soc. Testing Matls.—Advance Paper*, no. 45, for mtg., June 24-28, 1929, 8 pp., 9 figs.

Large fatigue-testing equipment of rotating cantilever type is described; purposes of larger equipment is to obtain results of greater uniformity for non-uniform material such as in weld metal or castings, and to test model rotors and other specimens having stress-concentration effects due to presence of fine machined detail; certain tests on welds are discussed from standpoint of their bearing on development of large machines.

METALS HARDENING

Hardening and Super-Hardening. *Metallurgist (Supp. to Engineer, Lond.)*, July 26, 1929, pp. 99-100.

Discussion of Cloudburst method employed by Herbert in subjecting surface of hardened piece of steel to impact from steel balls allowed to fall upon it; steel in hardest condition put by quenching is yet capable of undergoing plastic deformation by cold working; possible important method of coun-

teracting those surface defects at present limiting useful life of material in service under fatigue conditions.

METALS TESTING

WEAR. Wear of Metals in Contact with Paper (Verschliessversuche mit Metallen gegen Papier), W. Mauksch. *Zeit. fuer Metallkunde (Berlin)*, vol. 21, no. 6, June 1929, p. 189, 1 fig.

Results of tests carried out by Siemens-Konzern to determine best material to use for ticket-printing machine; metals tested were copper, phosphorus, bronze, Krupp nonmagnetic steel and tool steel; copper and bronze showed least resistance to wear; whereas hardened steel showed greatest resistance.

MICROSCOPES

METALLURGICAL. A Microscope for Metallurgical Work. *Iron and Steel Industry (Lond.)*, vol. 2, no. 10, July 1929, p. 321, 2 figs.

Description of Leitz large metallographic microscope of Chatelier-Guertler inverted type claimed to be particularly suitable for most exacting photomicrographic work.

NITRIDATION

The Nitriding of Special Steels, S. C. Alexander. *West. Machy. World*, vol. 20, no. 6, June 1929, pp. 217, 14 figs.

Methods of producing hardest known steel surfaces are discussed; effect of nitrogen on steel; nitriding process and equipment; character of case produced; special steels for nitriding; advantages of process.

Surface Hardening of Steel by Nitrogen Process, H. W. McQuaid. *Traction Shop and Roadway*, vol. 11, no. 6, June 1929, p. 165.

Results of experiments made by Timken-Detroit Axle Co.; addition of nitrogen instead of carbon to outer portion causes surface hardening of steel; molybdenum reduces brittleness; aluminum important element; commercial process of nitriding. Paper presented before Am. Soc. Mech. Engrs.

Nitriding, V. O. Homerberg. *Black and White (Metal Edition)*, vol. 2, no. 1, June 1929, pp. 12-18, 7 figs.

Development of nitriding by Fry in Krupp Works, Germany, is outlined; tables of analysis of physical properties of three nitralloy steels after proper heat treating and before nitriding; limitations of nitriding process.

Nitride Hardening (Die Nitrierhaertung). *Kruppsche Monatshefte (Essen)*, vol. 10, June 1929, pp. 59-61, 6 figs.

Guiding rules for production of engine cylinders, etc. (Continuation of serial.)

OPEN HEARTH FURNACE PRACTICE

A Melting Record of Three Acid Open-Hearth Heats, W. E. Griffiths and C. E. Meissner. *Am. Soc. for Steel Treating*—TRANS., vol. 16, no. 2, Aug. 1929, pp. 257-275 and discussion) 275-277, 16 figs.

Paper presents complete logs of three acid open-hearth heats as made in 25-ton acid open-hearth furnace; records show effect of change in melting practice, and of adding silicon in ladle rather than in furnace; effect of various alloy additions on slag composition and metal bath analysis is depicted graphically.

Open-Hearth Materials at Edgar Thomson. *Blast Furnaces and Steel Plant*, vol. 17, no. 8, Aug. 1929, pp. 1195-1197, 4 figs.

Arrangement of sixteen 100-ton furnaces in Edgar Thomson works of Carnegie Steel Co.; quantities of various materials used on monthly basis; preparation of materials for charging.

Diffusion of Iron Oxide from Slag to Metal in the Open-hearth Process, C. H. Herty. *Am. Inst. of Min. and Met. Engrs.—Tech. Pub.*, no. 229, for mtg. Sept. 1929, 18 pp., 2 figs.

Presentation of data obtained during investigation of deoxidation with silicon, to show fundamental principles governing diffusion of iron-oxide from slag to metal; some data being lacking, assumptions were made on metal viscosity and effect of temperature on diffusion; results given should be regarded as preliminary.

OPEN HEARTH FURNACES

REGENERATORS. Calculation of Open-Hearth Regenerators (Berechnungen von Waermetauschern bei Siemens-Martin-Oefen), B. Lubojatzky. *Feuerfest (Leipzig)*, no. 5, May 1929, pp. 85-89, 6 figs.

Discussion of laws governing absorption of heat by refractory bricks, most suitable dimensions for checkerwork in regenerators; weight of checkerwork and height of gas and air chambers required according to size of open-hearth furnace (expressed in tons of steel). (To be continued.)

Large-Scale Tests on Experimental Regenerative Chamber (Grossversuche an einer zu Studienzwecken gebauten Regenerativ-Kammer), F. Kofler. *Archiv fuer das Eisenhuettenwesen (Duesseldorf)*, vol. 3, no. 1, July 1929, pp. 25-42, 31 figs.

Structural characteristics of open-hearth regenerator are described; first tests were unsuccessful because checkerbrick was not sufficiently tight and large quantities of false air was absorbed; as results of special tests, brickwork was made completely air tight by use of cement filling and asphaltic mass; results of temperature measurement of gas, brick, and blast; temperature inside of brick.

TILTING. Design and Operation of 200-Ton Tilting Open-Hearth Furnace for the Talbot Process (Bau und Betrieb eines 200-t-Siemens-Martin-Ofens fuer das Talbot-Verfahren), W. Alberts. *Stahl und Eisen (Duesseldorf)*, vol. 49, no. 27, July 4, 1929, pp. 977-989, and (discussion), pp. 989-990.

Description of complete plant of Vereinigte Stahlwerke, Huette Ruhrort-Meiderich, includng crane, gas and air valves, and chambers; furnace details; gas and air admission; operating results.

TEMPERATURE MEASUREMENT. Temperature Measurements of Open-Hearth Furnaces (Temperaturmessungen an Siemens-Martin-Oefen), A. Schack. *Archiv fuer das Eisenhuettenwesen (Duesseldorf)*, vol. 3, no. 1, July 1929, pp. 7-11 and (discussion) 11-12, 2 figs.

Flow pyrometer for measurement of gas

temperatures up to 1600 deg. Cent. is described and results of measurements on heads and chambers of open-hearth furnaces are given; actual exhaust-gas temperature in decreasing draft seldom reaches 1600 deg.

PICKLING

Pickling as an Inspection, R. L. Rolf. *Black and White* (*Metal Edition*), vol. 2, no. 1, June 1929, pp. 3-7, 9 figs.

Adaption of pickling solutions as part of routine inspection in plant to show up defects is discussed; proper interpretation of results obtained by pickling are described.

PIPE, CAST IRON

CORROSION. Durability of Water Mains, H. Y. Carson. *Can. Engr.* (*Toronto*), vol. 57, no. 2, July 9, 1929, pp. 116-117.

Effect of soil and water corrosion on uncoated and cement-lined cast-iron pipe; durability of cast iron; physical and chemical aspects; rust on cast iron; removing incrustations.

RAILS

Report of Committee on Rail. *Am. Ry. Eng. Assn.—Bul.*, vol. 30, no. 315, Mar. 1929, pp. 1231-1324, 30 figs.

Report of Committee IV-Rail; subjects are detection of transverse fissures in track; rail failure statistics for 1927; transverse fissure statistics; cause and prevention of rail batter; economic value of different sizes of rail; reconditioning of battered or worn rail ends; tests of alloy steel rails.

MANGANESE STEEL. Steel Employed in the Manufacture of Railroad Track Equipment (Les aciers employés dans la fabrication des appareils de voil), A. Capron. *Industrie des Voies Ferrées et des Transports Automobiles* (*Paris*), vol. 23, no. 270, June 1929, pp. 231-235, 2 figs.

Comparison between manganese and non-manganese steels; durability, wear and abrasion; various methods of marking, welding and decarburation, are discussed.

MANUFACTURE. Comparative Study of Phenomena of Oxidation and Deoxidation in Manufacture of Rails by Basic and Open-Hearth Furnace (Etude comparative des phénomenes d'oxydation et de désoxydation dans la fabrication des rails par procédés Thomas et Martin), J. Wagner. *Revue de Métallurgie* (*Paris*), vol. 26, no. 6, June 1929, pp. 287-296, 9 figs.

Study of oxidation of liquid steel in basic and open-hearth processes, in order to determine effect of deoxidation on final product obtained by both processes; micrographic analysis of basic and open-hearth rail steel indicate that basic process is on par with open-hearth process in manufacture of rails.

SHEET STEEL

ANNEALING. Importance of Initial Annealing for High-Grade Sheet Steel, Its Influence on Erichsen Deep Drawing and on Structure (Die Bedeutung der ersten Gluehung fuer Qualitaetsfeinbleche, ihr Einfluss auf die Erichsen-Tiefung und das Gefuege), E. Marke. *Archiv fuer das Eisenhuettenwesen* (*Duesseldorf*), vol. 2, no. 12, June 1929, pp. 851-858, 25 figs.; see also brief abstract in *Stahl und Eisen*, vol. 49, no. 27, July 4, 1929, pp. 990-991.

Influence of annealing temperature and time on deep drawing and grain size of stamped and deep drawn sheets when submitted to one and to two pickling processes; practical value of results is set forth.

AUTOMOBILE BODIES. Automobile Body Maker Buys Steel on Basis of Performance, G. L. Kelley. *Iron Trade Rev.*, vol. 85, no. 2, July 11, 1929, pp. 84-85.

Policy of Edward G. Budd Manufacturing Co., Philadelphia, in buying, testing, and using steel sheets and strips; policy of cooperation with supplier of sheets and strips rather than insistence upon rigid specifications preferred; production first objective.

COLD ROLLING. Influence of Tapping and Annealing Temperature on Mechanical Properties and Structure of Cold Rolled Sheets (Der Einfluss der Stichabnahme und der Gluehtemperatur auf die mechanischen Eigenschaften und das Gefuege von kaltgewalzten Feinblechen), A. Pomp and L. Walther. *Archiv fuer das Eisenhuettenwesen* (*Duesseldorf*), vol. 2, no. 12, June 1929, pp. 859-865, 30 figs. See also brief abstract from *Stahl u. Eisen*, vol. 49, no. 26, June 27, 1929, pp. 941.

Results of cold rolling at 650, 750 and 920 deg. Cent.; testing of annealed sheets; notes on Erichsen deep drawing, yield point, tensile strength, elongation, and grain analysis.

SILVER-COPPER ALLOYS

Silver-Copper Eutectic (Untersuchungen ueber das Silber-Kupfereutektikum), J. A. A. Leroux and E. Raub. *Zeit. fuer Anorganische und Allgemeine Chemie* (*Leipzig*), vol. 178, nos. 1-3, Jan. 1929, pp. 257-271.

Formation of primary silver and copper-rich mixed crystals simultaneously with eutectic in cooling of silver-copper alloys containing 68-75 per cent silver is not always due to super-cooling; explanation is in greater rate of crystallization of copper-rich as compared with silver-rich crystals; microstructure of eutectiferous alloys of this system has been studied both before and after homogenization.

STAINLESS STEEL

Stainless Steels and Their Development (Die rostfreien Staehle und ihre Entwicklung), R. Schafer. *Giesserei-Zeitung* (*Berlin*), vol. 26, no. 13, July 1, 1929, pp. 261-271, 28 figs.

Review of development; theory of rust and corrosion; test with stainless steels, importance of heat treatment; fields of application.

HEAT TREATMENT. Heat Treatment of Stainless Steel (Waermebehandlung nichtrostender Staehle), A. Nauck. *Maschinen-Konstrukteur* (*Leipzig*), vol. 62, no. 11, June 1, 1929, pp. 252-253.

Process is briefly outlined for steels with from 13 to 15 and from 15 to 25 per cent chromium content.

STEEL

CARBON TRANSFORMATION. The Ac1 Range of Carbon Steel and Related Phenomena, A. Hultgren. *Am. Soc. for Steel Treating*—TRANS., vol. 16, no. 2, Aug. 1929, pp. 227-256, 17 figs.

Previous investigators have shown by other methods that transformation of pearlite into austenite on heating requires temperature range for its completion; present author by microscopic study of quenched specimens has shown progress of this transformation; three factors causing this transformation are: presence of alloy elements, heterogeneity due to segregation on solidification, slow diffusion rate of carbon and possibly other elements; several conclusions and opinions are given based on observation made in this study.

COLD WORKING. Strength and Structure Studies of Cold-Rolled and Annealed Strip Steels under Effect of Different Pretreatments (Festigkeits- und Gefuegeuntersuchungen an kaltgewalzten und gegluehten Bandstaehlen, etc.), A. Pomp and H. Poellein. *Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung (Duesseldorf)*, vol. 11, no. 10, 1929, pp. 155-184, 130 figs. partly on supp. plates.

Influence of cold rolling on strain hardening (tensile strength, elongation, and hardness), and structure of strip steel of increasing carbon content and different structure formation; influence of different heat treatments on yield point, etc.; practical applications of results. Bibliography.

ELASTIC LIMIT. Martin Elastic Limit Steel, P. G. Rouse. *Engineer (Lond.)*, vol. 148, no. 3836, July 19, 1929, p. 71, 2 figs.

Discussion of microstructure and manufacture of Martinel steel which is special quality steel subjected after rolling to special heat treatment which ensures formation of microstructure most favorable to greatest elastic strength of steel; reference made to paper by F. G. Martin describing development of steel; use of Martinel steel for parts of Empress of Britain.

RIMMED. The Physical Chemistry of Rimmed Steel, J. E. Carlin. *Am. Soc. for Steel Treating*—TRANS., vol. 16, no. 2, Aug. 1929, pp. 293-297.

First part of article deals briefly with early method of manufacture of low carbon steels by basic open-hearth process, and start and development of rimming process; second part explains rimmed steel from physical chemistry standpoint.

TEMPERATURE EFFECT. The Response of Steels at Elevated Temperatures, W. H. Hatfield. *West of Scotland Iron and Steel Inst.—Jl. (Glasgow)*, vol. 36, no. 5, Feb. 1929, pp. 60-65 and (discussion) 65-70, 2 figs.

Discussion of response of steels at elevated temperatures in regard to effect of temperature on mechanical and physical properties of steel, and in regard to possibility of relative permanence of structure when plant, or part is in operation; strength of steels as affected in steam range of temperature and resistance as regards oxidation; resistance of heat-resisting steels to scaling.

STEEL ANALYSIS

AUSTENITE DETERMINATION. Determination of Austenite Content by Measurement of Magnetic Saturation Value and Phenomena Occurring with Annealing of Hardened Steels (Die Bestimmung des Austenitgehaltes durch Messung des magnetischen Saettigungswertes und die Vorgaenge beim Anlassen gehaerteter Staehle), E. Maurer and K. Schroeter. *Stahl u. Eisen (Duesseldorf)*, vol. 49, no. 26, June 27, 1929, pp. 929-940, 16 figs.

Determination of austenite content in quenched steels; magnetic saturation value, specific gravity, and Brinell hardness of different steels after quenching in water and oil and after dipping them in liquid air; change in these values through annealing.

OXIDE DETERMINATION. Oxides in Steel. *Metallurgist (Supp. to Engineer, Lond.)*, June 28, 1929, pp. 90-92.

Brief review of research work of Hessenbruch and Oberhoffer, R. von Seth, and Thanheiser and Mueller, on hot-extraction process; by this method only oxides of iron and manganese are completely reduced; silica and alumina are only partially reduced up to temperature of 1500 deg. Cent.; practice of estimating oxygen in successive samples in same melt is not to be recommended; hot-extraction method therefore appears to offer very little advantage over hydrogen-reduction method as regards results.

STEEL CASTINGS

MICROSTRUCTURES. Critical Examination of Steel Castings, G. F. Gillott. *Foundry Trade Jl. (Lond.)*, vol. 41, nos. 674 and 675, July 18 and 25, 1929, pp. 38-40 and 59-60, 22 figs.

July 18: Application of methods employed in studying sectioned ingots to steel castings are discussed including macroscopical and microscopical examination and object of annealing. July 25: Use of microscopical examinations as routine test and keeping of systematic records of microstructure of test bars; occurrence of V-segregation; contraction cavities and blowholes; interdendritic weakness; explanations of radiographs; "chill" effect.

STEEL CORROSION

Corrosion and Water Flow. *Gas Jl. (Lond.)*, vol. 136, no. 3449, June 26, 1929, p. 915, 2 figs.

Brief note on experiment shown before Institution of Civil Engineers; perpendicular jet of water allowed to impinge on circular steel plate, 10 in. diam., from height of one inch, at varying velocities; circular wave formed at center; steel in contact with water outside wave was etched by oxygen bubbles; test demonstrated that turbulent flow through tubes of economizer will brush off oxygen that would otherwise corrode.

STEEL EMBRITTLEMENT

Red Shortness (Ein Beitrag zur Frage des Rotbruches), A. Niedenthal. *Archiv. fuer das Eisenhuettenwesen (Duesseldorf)*, vol. 3, no. 1, July 1929, pp. 79-97, 59 figs.

Results of tests to determine degree and

area of red embrittlement; influence of sulphur and oxygen on blue brittleness; investigation of causes and elimination of hot brittleness caused by sulphur or oxygen; influence of sulphur or oxygen on strength.

STEEL FATIGUE

Progressive Fractures of Steel. *Black and White (Metal Edition)*, vol. 2, no. 1, June 1929, pp. 28-30, 5 figs.

Progressive fractures and means of eliminating them to certain extent are outlined; expression often used to explain fatigue, or progressive failure, to effect that it has taken place because of "crystallization" of steel, is entirely incorrect; it is type of failure which often occurs in material that may be entirely satisfactory both as to analysis and heat treatment.

STEEL FOUNDRY PRACTICE

Producing Steel Castings in the Modern Foundry, C. W. Veach. *Foundry*, vol. 57, no. 14, July 15, 1929, pp. 604-607, 2 figs.

Selection of raw materials for steel castings is discussed; arrangement of stockyard suitable for containing materials for supplying five 35-ton furnaces; advisability of substituting cheap refractories for reliable materials on first cost basis; it is not good method of comparison. (Continuation of serial.)

Producing Steel Castings in the Modern Foundry, C. W. Veach. *Foundry*, vol. 57, no. 15, Aug. 1, 1929, pp. 648-650 and 673.

Melting down, refining heat, and operation of furnace during periods of charging must be conducted carefully if good product is desired; technical knowledge required; effect of sulphur on properties of steel. (Continuation of serial.)

STEEL HEAT TREATMENT

Heat Treatment of Steel, H. M. Boylston. *Black and White (Metal Edition)*, vol. 2, no. 1, June 1929, pp. 21-27, 1 fig.

Heat treatment of structural alloy steels is taken up, covering nickel steels, austenitic nickel steels, and nickel-chromium steels, series 3100, 3200, 3300 and 3400; critical points of nickel-chromium steels.

Principles of the Heat Treatment of Steel, Metallurgical Staff of Bureau of Standards. Cleveland, American Society for Steel Treating, 1928, 93 pp., $1.50.

Presents elementary facts and principles in concise form and in simplest terms possible; book is intended as introduction to more extensive treatises and periodicals for use by beginners and practical men; valuable bibliography is included; book is confined to carbon steels. Eng. Soc. Lib.

Fundamentals Underlying the Heat Treatment of Steel, O. W. Ellis. *Can. Machy. and Mfg. News (Toronto)*, vol. 40, nos. 13 and 14, June 27 and July 11, 1929, pp. 106-108 and 46-50, 10 figs.

June 27: Furnace atmosphere and furnace cleanliness of fundamental importance in heat treatment of steel; uniformity of temperature; correct temperatures to which steel should be heated for various types of treatment; structural changes occurring; critical point in iron containing carbon. July 11: What happens when steel is heated to various temperatures and cooled with fair rapidity; relationship of constituents of steel: martensite, ferrite, pearlite, austenite and carbide. Paper presented before Am. Soc. Steel Treating.

A Study of Burning and Overheating of Steel, W. E. Jominy. *Am. Soc. for Steel Treating*—TRANS., vol. 16, no. 2, Aug. 1929, pp. 298-313, 8 figs.

Effect of oxidizing and reducing atmosphere on steels heated for forging were studied and results given. (To be continued.)

QUENCHING. On the Lattice—Constant of Quenched Carbon Steels, S. Sekito. *Tohoku Imperial University—Science Reports (Sendai)*, vol. 18, no. 1, May 1929, pp. 69-77, 3 figs.

It is shown that axial ratio of tetragonal lattice diminishes in magnitude from surface to interior; axial ratio of tetragonal lattice increases with carbon content, as well as with quenching temperature. (In English.)

On the Distribution of Austenite in Specimens of Quenched Carbon Steels, K. Honda and A. Osawa. *Tohoku Imperial Univ. Science Reports (Sendai)*, vol. 18, no. 1, May 1929, pp. 47-58, 6 figs.

By means of X-ray analysis, it is confirmed that in quenched specimens, amount of retained austenite is greater in outer layer than in inner; for same steel this difference increases as quenching temperature is raised, and for same quenching temperature, it increases with carbon content. (In English.)

STEEL RESEARCH

The Application of Science to the Steel Industry, W. H. Hatfield. *Am. Soc. for Steel Treating*—TRANS., vol. 16, no. 2, Aug. 1929, pp. 278-292, 18 figs.

This section covers carbon and high speed tool steels; accompanied by photomicrographs of each in variously treated conditions; results are described of an investigation of table knives, razors, etc., to determine characters of those possessing good cutting edges as compared to those with poor cutting edges; some operations to be observed in manufacture of cutlery are discussed. Sixth section of third Edward De Mille Campbell Memorial Lecture.

GREAT BRITAIN. Steel Research. *Metallurgist (Supp. to Engineer, Lond.)*, June 28, 1929, pp. 81-82.

Editorial comment on formation of Steel Research Council, which is to have at its disposal funds of order of 20,000 pounds per annum, one-half of which is to be provided by Department of Scientific and Industrial Research.

STEEL TESTING

Elastic Limit of Shearing and Punching Stresses (La limite d' élasticité au cisaillement), C. Frémont. *Génie Civil (Paris)*, vol. 95, no. 2448, July 13, 1929, pp. 40-42, 9 figs.

Excerpt from bulletin 81 of Etudes Expérimentales de Technologie Industrielle; photographic study of deformations and permanent strains due to shearing and punching stresses in mild steel.

News of the Chapters

SCHEDULED MEETING NIGHTS OF CHAPTERS

For the convenience of visiting members, those chapters having scheduled meeting nights are listed below:

BOSTON—First Friday, with the exception of October 7. H. E. Handy, secy., Saco-Lowell Shops, Biddeford, Me. Phone, Biddeford 1.

October 7—Smoker at the University Club.
November 1—Inspection trip to Norton Company, Worcester, Mass.

CHICAGO—Second Thursday. J. A. Comstock, secy., People's Gas Light & Coke Company, Chicago.

September 5—Aeroplane Metallurgy .... J. B. Johnson
October 10—Influence of Temperature on Physical Properties of Metals .... L. W. Spring
November 14—Tool Steels .... F. R. Palmer
December 12—X-Ray Investigations .... E. W. Page
January 9—Carburizing .... R. G. Guthrie
February 13—Fatigue of Metals .... H. F. Moore
March 13—Welding .... J. B. Green
April 10—Corrosion .... F. N. Speller
May 8—Inspection Trip.
June 14—Annual Picnic.

CINCINNATI—First Thursday, with the exception of May 2. N. C. Strohmenger, secy., Tool Steel Gear and Pinion Co., Cincinnati.

October 3—Inspection Trip to Aluminum Industries, Inc.
November 7—Relation Between Structure, Machinability and Hardness in Alloy Steel .... W. W. Leffler
December 5—Forgings.
January 2—Subject will be announced later .... R. G. Guthrie
February 6—Gears .... Mr. Vonderheide
March 6—Tri-Chapter Meeting of Columbus, Dayton and Cincinnati Carboloy .... S. L. Hoyt
April 3—Fatigue .... H. W. Gillett
May 2—Safety in Heat Treating Plants .... R. G. Adair

DETROIT—Third Monday. J. W. Robinson, secy., Higgins-Bothwell Co., Detroit.

October 21—Gas Carburizing .... R. G. Guthrie
November 18—Nonferrous Automotive Practice .... W. M. Corse
December 16—Christmas Party.
January 20—Recent Aircraft Developments.... Speaker to be announced later
February 17—X-Ray .... G. L. Clark
March 17—Nitriding of Steel .... V. O. Homerberg
April 21—Steel Making .... S. G. Hildorf
May 12—Tungsten Carbide Tools .... S. L. Hoyt

HARTFORD—Second Tuesday. H. I. Moore, secy., Firth-Sterling Steel Company, Phone 4-3562 Hartford.

October 8—Manufacture of Alloy Steel .... L. S. Hamaker
November 12—Alloys and Their Effects in Tool Steels .... J. P. Gill
December 10—Results Obtained from Modern Hardening Equipment.. .... Jordan Korp
January 14—Impressions of European Gray Iron Foundry Practice.... .... R. F. Harrington

February 11—Corrosion Resisting Steels ....F. R. Palmer
March 11—Visitation and Meeting at the New Heat Treating Plant of the Stanley P. Rockwell Company.
April 8—Constructive Criticism of Steel Hardening Theories....E. C. Bain
May 13—Light Alloys Used in Aircraft Construction........E. H. Dix, Jr.

ONTARIO CHAPTER—L. F. Fitzpatrick, secy., Flexible Shaft Company, Ltd., Toronto, Canada.

October 11—"Large High Duty Forgings"......................L. H. Fry
November 1—"Testing Methods and Equipment"............E. A. Allent
January 10—"Carboloy"..S. L. Hoyt
February 7—"Heat Resisting Alloys" or "Nitriding".........T. H. Nelson
(Subject to be definitely decided later)

PITTSBURGH—First Thursday. H. L. Walker, secy., Box 521, Pittsburgh, North Side Station.

September ....G. M. Eaton
October ....W. Trinks
November ....Zay Jeffries
December ....Dance
January ....H. L. Frevert
February ....R. L. Templin
March ....B. D. Saklatwalla
April ....J. B. Johnson
May ....Not definitely arranged
June ....Outing

SYRACUSE—Grover Farnsworth, secy., 634 Richmond Ave., Syracuse.

October—Carboloy ....G. N. Sieger
November—Chromium Plating ....Wm. Blum
December—Cold Heading and Upsetting ....Swan Hillman
January—Corrosion, Stainless Iron and Steel ....T. H. Nelson
February—Ajax Electric Furnaces ....F. T. Chestnut
March—Forgings ....J. C. Killman
April—Nitriding ....V. O. Homerberg

WORCESTER—Milton H. Frommann, secy., Reed and Prince Mfg. Co., Worcester.

October 17—Machinability of Metals ....A. H. d'Arcambal
November 1—Joint Meeting with the Boston Chapter at the Norton Plant, Worcester, Mass.
December 4—European Steel Plants ....William Hague
Film—The Story of Steel by the U. S. Steel Corp.
January 9—Stainless Steel ....Speaker to be announced later
February 12—Diesel Engine for Aircraft...............................
......................Speaker from Packard Motor Car Company
March 13—Use of Wrought Copper Alloys................D. K. Crampton
April 2—Design in Respect to Heat Treating ....G. M. Eaton
May 8—Annual Question Meeting and introduction of new officers.

STANDING OF THE CHAPTERS

DURING the month of August there were 88 new and reinstated members, while 42 were lost through non-payment of dues and 4 through resignations and deaths, leaving a net gain of 42 members for the month.

The total membership of the society on August 1, 1929, was 5615 and the chapters appear in the following order of membership:

GROUP I—Chicago with a gain of eight extended its lead to seventy members over Detroit in second place. The other chapters in this group remained the same, New York showing a nice gain of six members and going to within one of tying Philadelphia for fourth place.

GROUP I		GROUP II		GROUP III	
1. Chicago	558	1. Los Angeles	229	1. Ontario	141
2. Detroit	488	2. New Jersey	150	2. Tri City	108
3. Pittsburgh	401	3. Milwaukee	148	3. New Haven	99
4. Philadelphia	337	4. Hartford	143	4. Worcester	80
5. New York	336	5. Lehigh Valley	140	5. Rochester	77
6. Cleveland	323	6. Golden Gate	139	6. Washington	70
7. Boston	257	7. Cincinnati	104	7. Rhode Island	66
		8. St. Louis	99	8. Schenectady	64
		9. Dayton	91	9. Southern Tier	49
		10. Indianapolis	90	9. Rockford	49
		10. Buffalo	90	11. Columbus	46
		10. Canton-Mass.	90	12. Springfield	39
		13. Syracuse	88	13. Notre Dame	30
		14. Montreal	77	14. Fort Wayne	26
		15. North West	70		

GROUP II—Los Angeles shows a gain and still heads this group with a lead of seventy-nine members over its nearest rival. New Jersey with a gain of one advanced from third to second place, passing Milwaukee.

An interesting triple tie has developed between Indianapolis, Buffalo and Canton-Massillon for position ten, with ninety members each.

GROUP III—Ontario again continues its forward march and has a lead of thirty-three members over Tri City in position two. Southern Tier and Rockford are still engaged in a battle for position nine, while the other chapters in the group remained the same.

CHICAGO CHAPTER

CHICAGO CHAPTER held a pre-convention booster meeting on September 5th, at the City Club. The occasion was made the second annual ladies' night, and, consequently, the dinner was brightened by the presence of the fair sex at most of the tables. Because of the tremendous interest aroused by aviation in recent months, it was thought that an "Aviation Meeting" would be of interest. This meeting was designated as such, therefore, and both afternoon and evening were given over to examination and information concerning flying.

The party gathered in the afternoon at the Municipal Airport, and inspected the terminal facilities and shops of the Stout, Universal, and National flying companies. A sight-seeing flight in the all-metal Ford planes had been planned, but a 300-foot ceiling prevented even the mails from leaving Chicago that day. The party there adjourned to the club for dinner.

Chairman Steever, after officially welcoming the ladies, introduced Pilot Harold Yeomans of the Universal Air Lines. Mr. Yeomans told of the flying instruction course given by the army, and emphasized the safety in the regular commercial flying of today. He was followed by Mr. Robert M.

Hoffman, Traffic Manager of the Stout Air Lines, who also featured the safety side when flying on commercial lines with licensed pilots. Putting the chances of accident into figures, Mr. Hoffman gave one accident to the equivalent of 12,410 round trips between Chicago and Detroit.

Mr. H. H. Harris, of the General Alloys Company, was then introduced. Mr. Harris had been forced down by the fog that afternoon in attempting to fly from Champaign to Chicago. He completed the trip by train. In his talk, however, he maintained that the airplane of today is a commercial success.

The technical speaker of the evening was a past chairman of Dayton Chapter, J. B. Johnson, Chief of the Material Branch of the Air Corps at Wright Field. Mr. Johnson traced the history of airplane structure from the original wood and fabric construction to the present all metal planes. He dwelt particularly on the welded steel construction and on the importance of the light alloys. His talk was illustrated with numerous examples of all types of construction. Several reels of motion pictures closed Mr. Johnson's paper. These pictures were war department films illustrating some of the spectacular phases of army flying, and were exceedingly interesting.

D. L. Colwell.

DETROIT CHAPTER

The Detroit Chapter announces that it is again cooperating with the Cass Technical High School and with the College of the City of Detroit in the evening courses in ferrous and nonferrous metallurgy and metallography to be offered from Sept., 1929, to June, 1930.

GOLDEN GATE CHAPTER

The Golden Gate Chapter is again sponsoring the course in practical metallurgy given at the Humboldt Evening High School at San Francisco.

For the last two years the chapter felt that all was not being done which could be done in an educational way. The need of a course which would carry more of a practical aspect was decided upon as the ultimate goal. Due to a great extent to the efforts of Frank Drake sufficient funds were raised for the needs of the course. A large laboratory room at the Humboldt High School was obtained and the laboratory equipment purchased.

Starting Jan. 10 of this year, one lecture each week for eighteen weeks was given, under the direction of Dr. W. J. Crook of Stanford University. The laboratory course was planned to run for thirty-six weeks.

This fall term the lectures will again be given. In addition a laboratory course will be started for those completing the lectures last spring. The other laboratory section will be a continuation for those men who have now completed the first eighteen weeks. The same instructors as for last term will be in charge.

PHILADELPHIA CHAPTER

The year 1928-29 has been a very successful one from many standpoints, including those of interesting meetings, good attendance, maintenance of good membership standing, splendid financial standing, a most

successful handling of the educational work carried on at Temple University.

Of particular interest are the several closing meetings of the year's activities. The meeting held on March 29 stands out as a veritable milestone in the chapter's history. The meeting took the form of a symposium on "Fuels for the Heat Treatment of Steel." The papers of the evening were, "Use of Electric Furnaces for the Heat Treatment of Steel," by A. N. Otis, General Electric Co.; "The Gas Furnace in Relation to Heat Treatment," by Frank Trembly, Surface Combustion Co.; "The Use of Fuel Oil for the Heat Treatment of Steel," by E. P. Kiehl, Atlantic Refining Co.; and "General Discussion of the Fuels Used in the Heat Treatment of Steel," by M. J. Conway, Lukens Steel Co.

The April meeting was given over to a discussion of a very interesting subject, "Properties of Steel at Elevated Temperatures," and the papers were read by John L. Cox, Midvale Co., and Norman L. Mochel, Westinghouse Electric and Mfg. Co.

The final meeting was a plant visitation to the Autocar Co. at Ardmore, Pa. The Autocar Co. acted as splendid hosts, conducted the members through the plant and treated them to a full course dinner, embellished with dancing and singing by a troupe of entertainers.

This final meeting also marked the induction into office of the newly elected officers. Dr. Patch, the retiring chairman, rendered a fitting and worthy accounting of his stewardship during the past year. The Philadelphia Chapter as a whole is deeply appreciative of the splendid work done by Dr. Patch and his co-workers on the executive committee.

The newly elected officers were introduced as Henry Allen, metallurgist, Henry Disston and Sons., Inc., as chairman for the year 1929-30, Gustav Peterson, Ludlum Steel Co., as vice-chairman, and Richard Jordan, and Claude L. Roth to the executive committee. Mr. Allen treated the chapter to an innovation from the standpoint of newly elected chairmen, when he delivered a well-written and pointed address of appreciation to his elevation in office, having previously been vice-chairman.

A chapter activity, which is more or less without widespread publicity, is that concerned with the work of the Alumni Society of the course in metallography at Temple University. The Alumni Society had two very important meetings, insofar as their work in keeping interest in the course was concerned. One was their meeting, May 2, when they, together with The Wiedemann Machine Co., were hosts to the metallurgy class at the plant of the Wiedemann Machine Co. The other main event was a plant visitation to the Brown Instrument Co. and the Leeds and Northrup Co., manufacturers of pyrometric equipments, etc.

The Philadelphia Chapter is now planning the Year Book for 1929. It would be a pleasure to have requests for copies of this book to be sent to members of the society at large. Just address a letter to the secretary, A. W. F. Green, 407 Shoemaker Road, Elkins Park, Philadelphia.

A. W. F. Green.

Items of Interest

IN order that engineering science may be adequately interpreted to the public and that its relation to the progress during the past century may be graphically depicted, leading engineering authorities in this country have been asked to serve on the National Research Council Science Advisory Committee to the Chicago World's Fair Centennial Celebration to be held in 1933. The engineers serving on the committee at the request of the National Research Council will strive to formulate a philosophy for the Exposition of engineering knowledge which will reveal the advancement made in the United States since the beginning of the so-called Industrial Revolution up to the present time.

The engineering members of the Advisory Committee are such men as Dean Anson Marston of the Department of Engineering of Iowa State College of Agriculture and Mechanic Arts, who will prepare data on civil engineering progress; William L. Batt of New York for mechanical engineering; C. F. Kettering of the General Motors Research Corporation at Dayton for automotive data; W. H. Eisenman, secretary of the American Society for Steel Treating, who will report on steel treating; S. H. McCrory, chief of the Division of Agricultural Engineering of the U. S. Bureau of Public Roads, who will furnish agricultural engineering data; Prof. A. H. White of the Department of Chemical Engineering of the University of Michigan, on chemical engineering; Ross G. Purdy, secretary of the American Ceramic Society, on ceramics; Prof. Arthur N. Talbot, of the Engineering Experiment Station of the University of Illinois, on materials testing; Arthur D. Little of Cambridge, Mass., on chemistry; Prof. Colin G. Fink of the Department of Chemical Engineering of Columbia University, on electro-chemistry; Prof. C. K. Leith of the University of Wisconsin, on geology; W. E. Wrather of Dallas, Texas, on petroleum geology, and Dr. Isaiah Bowman of the American Geographical Society, and Dr. Gilbert Grosvenor of the National Geographic Society, on geography.

The National Research Council Science Advisory Committee was formed at the request of the trustees of the Chicago fair for advice and active aid in presenting the progress made during the past century by science in industry. The Committee is made up of leading engineers and scientists of the United States and will cooperate with the executive committee in formulating ideas for the presentation of this unique display.

Members of the general committee will submit to the executive committee their suggestions for a central plan that will visualize, in concrete tangible form, the whole development of industry from the time applied science began to dominate this development. This plan will be a demonstration of the progress pure and applied science has made in the march of industry. It is the hope of the executive committee to have the suggestions coordinated into this central plan by early fall.

(Continued on Page 22, Adv. Sec.)

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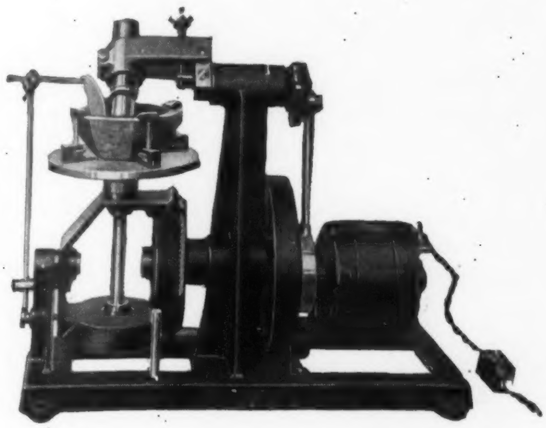

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According to present plans the Chicago World's Fair will be of an entirely different character from any exposition heretofore held. The present plans are that the material progress made during the past one hundred years be displayed in such a way that visitors, in whatever field they may be interested, will be enabled to form not only a picture of the existing state of the art but to form an idea of the development of that art from its genesis, so far as possible, in the fields of pure science knowledge.

The members of the Executive Committee of the Advisory Board are: Dr. Frank B. Jewett, chairman; Dr. George K. Burgess, Washington; Gano Dunn, New York; Dr. Vernon Kellogg, Washington; Prof. M. I. Pupin, New York; Dr. Max Mason, New York, and Dr. William Allen Pusey, of Chicago. Maurice Holland of New York has been appointed executive secretary and the committee has established offices at 40 West 40th Street, New York City.

Alexander L. Feild has resigned his position with the Union Carbide and Carbon Research Laboratories, Inc., 30 East 42nd Street, New York, N. Y., and is now associated with the Simonds Saw and Steel Company, 89 Broad Street, Boston, Mass., in the capacity of Research Engineer. Mr. Feild is located at the Simonds Steel Mills, Lockport, N. Y. In his new position he will be in charge of an extensive program of experimental and development work on electrometallurgical processes and particularly on the electric furnace production of alloy steels. Mr. Feild is best known for his investigations in the Bureau of Mines on blast furnace slag, on the effects of zirconium in steel with the Electro Metallurgical Company and more recently on the manufacture of stainless iron with the Central Alloy Steel Corporation. He has been active in the affairs of the American Institute of Mining and Metallurgical Engineers for a number of years and at the present time is vice-chairman of the Iron and Steel Division and a member of the Committee on the Physical Chemistry of Steel-making, of which committee he was chairman last year.

The Leeds and Northrup Co., 4901 Stenton Ave., Philadelphia, has available to those interested the following catalogues and bulletins which have been recently issued: "Photometers," "Optical Pyrometers," "Potentiometer Pyrometers," "Homo Method for Productive Tempering," "Students' Potentiometer," "Potentiometers for Temperature Control in Oil Refining," "Temperature Measurements in Generator Rotating Fields," "Notes on the Kelvin Bridge."

Halcomb Steel Co. announces that L. Sjolander of the Cleveland Wire Spring Co. is the winner of the set of stainless steel golf clubs given by that company in a drawing contest held during the recent National Metal Exposition.

The Driver-Harris Co., Harrison, N. J., has available for distribution a brochure entitled "Nichrome the Heat Resisting Alloy." This pictures various applications of heat resisting alloys made by this company.

(Continued on Page 24, Adv. Sec.)

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